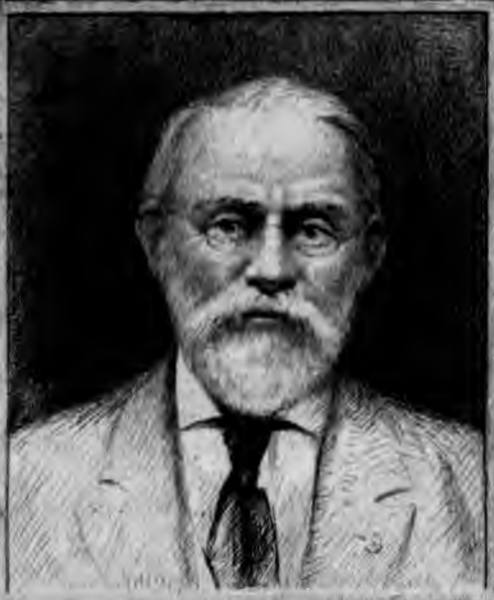

THE SCIENTIFIC MEMOIRS

OF

THOMAS HENRY HUXLEY

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SUPPLEMENTARY VOLUME

EDITED BY

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PREFACE

TO THE SUPPLEMENTARY VOLUME

WHEN it was discovered that owing to a bibliographical obscurity we had omitted the later portions of Huxley's "Survey Memoir" on fossil fishes from our collection, it became necessary to issue a supplement containing the important work which we had inadvertently passed over. The opportunity is taken to add three interesting essays by Huxley, which, though not altogether of the same character as the memoirs containing original discoveries of which this collection otherwise consists, yet have considerable interest for zoologists, and are not contained in the published edition of his more general essays.

E. RAY LANKESTER.

January, 1903.

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OF

THOMAS HENRY HUXLEY

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VESTIGES OF THE NATURAL-HISTORY OF CREATION TENTH EDITION. LONDON, 1853

The British and Foreign Medico-Chirurgical Review, vol. xiii., 1854, *pp.* 425-439.

IN the mind of any one at all practically acquainted with science, the appearance of a new edition of the 'Vestiges' at the present day, has much the effect that the inconvenient pertinacity of *Banquo* had upon *Macbeth*. "Time was, that when the brains were out, the man would die." So time was, that when a book had been shown to be a mass of pretentious nonsense, it, too, quietly sunk into its proper limbo. But these days appear, unhappily, to have gone by, and the same utter ignorance of the public mind as to the methods of science and the criterion of truth, which were evidenced to a Faraday by the greedy reception of the table-turning folly, have encouraged the author of the 'Vestiges' to venture upon a *tenth* edition, "with extensive additions and emendations." We doubt not that this edition—very pretty and well got up it is—will be as greedily swallowed by those to whom it is offered, as any of the other nine, to the great glory and no small profit, of its modest and ingenious author. We grudge no man either the glory or the profit to be obtained from charlatanerie, and we can hardly expect that those who are so ignorant of science as to be misled by the 'Vestiges,' will read what we have to say upon the subject; but a book may, like a weed, acquire an importance by neglect, which it could have attained in no other mode; and, therefore, it becomes our somewhat unpleasant duty to devote a few of our pages to an examination of some of the leading points of this once attractive and still notorious work of fiction: indeed we feel the more called upon to undertake

this criticism at present, since, as we shall see, the 'Vestigiarian' has bolstered up his case by the use of names and authorities, which, were it justifiable, might give a certain value to his statements.

It would be no less wearisome than unprofitable to go into a detailed examination of all the blunders and mis-statements of the 'Vestiges'—to drag to light all the suggestions of the false and suppressions of the true, which abound in almost every page, and which, in a work of such pretension, of such long elaboration, and so filled with whining assertions of sincerity, are almost as culpable, if they proceed from ignorance, as if they were the result of intention. We propose, therefore, to confine our attention to the fundamental proposition of the book and to some one or two of those matters connected with the biological sciences, which come more particularly within the province of this review.

The Vestigiarian modestly tells us, that none of his critics have rightly conceived "the fundamental proposition of the work" (Proofs, &c., lviii); and in answer to the reproach of superficiality, he says, that "to be a superficial book, it has been remarkably hard to understand" (Ibid). We really must suggest that difficulty of comprehension is by no means a test of depth of thought, and that it would be well to leave out, in the eleventh edition, the confession, that this book, so popular with the mob, is incomprehensible to the thinker. Obscurity is more often the result of the muddiness than of the depth of the stream of thought. This, by the way, however: for, lest we should fall under like condemnation, we quote here the author's own words, that "The actual proposition of the 'Vestiges' is 'creation in the manner of law,' that is, the Creator working in a natural course, or by natural means." (Proofs, lix.) Here then is the idea of the book, and if the author has not demonstrated this, it is so much waste paper. There is, however, one preliminary which must be settled before passing to the question of demonstration—namely, has this potent proposition, as it is here expressed, any intelligible meaning at all?

What is the sense of the terms "Law" and "Nature"? Nature is, of course, the totality of all laws, and therefore our inquiry is limited to the question of the meaning of "Law." As we prefer not to adopt any definition not admitted by our author, we will turn to his own pages though there really are authorities (Sir John Herschel, or Mr. John Mill, for instance), to whom we should give a preference—especially as the Vestigiarian does not pursue that pleasant and useful habit of being consistent with himself, but has one theoretical meaning, which he defines and writes about, and one practical, which he acts upon.

The former is brought forward *explicitly* in controversy; the latter *implicitly* in the body of the book. The former may be met with in the controversy with Dr. Hitchcock.

"Law, I have over and over again said, is merely a term of human convenience to express the orderly manner in which the will of God is worked out in external nature; and He must be ever present in the arrangements of the universe, as the only means by which they could be even for a moment sustained." (Proofs, lxii.)

We perfectly agree with this definition of Law; but suppose that we substitute it for the word law in the portentous formula we have cited above, thus—"Creation took place," "in the orderly manner in which the will of God is worked out in external nature," "he being immediately present;" and, stripped of unnecessary verbiage, it comes to this, that "Creation took place in an orderly manner, by the direct agency of the Deity." A proposition which is as old as the Book of Genesis.

As exhibited in controversy *explicitly*, then, the proposition of the 'Vestiges' is, as a scientific explanation of Creation, not a whit in advance of the notions entertained by our grandmothers; but the tacit, *implied* proposition which the author, whenever pressed, denies, but always acts upon, is very different. The Vestigiarian, in fact, with no small pride, contrasts this his own private notion—1. With the allowing of the existence of any "dominion of marvel;" 2. With the notion of creative fiats, interferences or interpositions of creative energy—with the need of a "special attention" "whenever a new family of organisms is introduced;" 3. With the "undignified" notion that the nodulosities and corrugations of a cephalopod are "worthy of the particular care of that same Almighty who willed at once the whole means by which infinity was replenished with its worlds."

What then is this real proposition of the 'Vestiges'? It is simply, exhibited in all its naked crudeness, the belief *that a law is an entity*—a Logos intermediate between the Creator and his works—which is entertained by the Vestigiarian in common with the great mass of those who, like himself, indulge in science at second-hand and dispense totally with logic. To use a phrase of M. Comte's—the mind of the Vestigiarian is in the metaphysic stage, and confounds its own abstraction with objective fact.

A few citations will abundantly bear out what we have said. Thus at p. 307, "natural laws" are said "to produce winds" and are "sometimes unusually concentrated in space or in time, so as to produce storms and hurricanes, by which much damage is done."

Again, at p. 307, we found the following mysterious passage:—

"The laws presiding over meteorology, life, and mind, are necessarily less definite, as they *have to produce* a great variety of mutually-related results."

"*Indefinite* laws"! "*which produce results*" *!!*

Once more—

"The Creator, then, is seen to have formed our earth, and effected upon it a long and complicated series of changes, in the same manner in which we find that he conducts the affairs of nature before our living eyes: that is, *in the manner of natural law.* This is no rash or unauthorized affirmation. . . . . It is a point of stupendous importance in human knowledge; here at once is the whole region of the inorganic taken out of the dominion of marvel, and placed under an idea of divine regulation, which we may endlessly admire and trust in." (p. 113.)

And again (p. 114) with regard to the modes of origin of organic bodies.

"The Eternal Sovereign arranges a solar or an astral system, by dispositions imparted primordially to matter; he causes, by the same majestic means, vast oceans to form and continents to rise, and all the grand meteoric agencies to proceed in ceaseless alternation, so as to fit the earth for a residence of organic beings. But when, in the course of these operations, fuci and corals are to be for the first time placed in those oceans, a change in his plan of administration is required. It is not easy to say what is presumed to be the mode of his operations. The ignorant believe the very hand of the Deity to be at work. Amongst the learned, we hear of 'creative fiats,' 'interferences,' 'interpositions of the creative energy,' all of them very obscure phrases, apparently not susceptible of a scientific explanation, but all tending simply to this,—that the work was done in a marvellous way, and not in the way of nature. Let the contrast between the two propositions be well marked. According to the first, all is done by the continuous energy of the divine will,—a power which has no regard to great or small: according to the second, there is a procedure strictly resembling that of a human being in the management of his affairs. And not only on this one occasion, but all along the stretch of geological time, this special attention is needed whenever a new family of organisms is to be introduced: a new fiat for fishes, another for reptiles, a third for birds; nay, taking up the present views of geologists as to species, such an event as the commencement of a certain cephalopod, one with a few new nodulosities and corrugations upon its shell, would, on this theory, require the particular care of that same Almighty

who willed at once the whole means by which INFINITY was replenished with its worlds!"

If the author of the 'Vestiges' really means by law, simply the *mode* in which the "Will of God"—who is ever present in the arrangements of the universe—takes effect, as he says he does, what meaning is there in the passages we have just quoted? If everything is the direct result of the Will of God, what does his theory differ from that of the "learned," at whom he sneers? If the Deity be ever present, and phenomena are the manifestation of his will—law being simply a name for the order in which these occur—what is every phenomenon but the effect of a "creative fiat," an "interference," an "interposition of creative energy?" If everything be the expression of the will of a present Deity—as the Vestigiarian affirms when it suits him—the introduction of every "new family or organism," *must* be an act of "special attention;" and upon his own showing, the Vestigiarian should believe, that the "corrugations and nodulosities" upon a cephalopod's shell, as much require "the particular care of the Almighty," as "the replenishment of infinity with worlds."

But, truly, what an entirely false and mean view of Nature is revealed in this very phrase, what utter snobbism and *philisterei* of conception. What is great and what is small in nature, from whose bountiful hand all things are poured out equally complete and equally perfect? Why should not the chambers of a cephalopod's shell be as worthy of the particular care of the Almighty in their production, as our Vestigiarian himself, or any of the other nebulæ? What are Alps and Andes but "corrugations and nodulosities" upon the mother earth, whose majesty he slanders? What are the worlds, whose magnitude excites his admiration, but "corrugations and nodulosities" upon the bosom of the infinite universe? We are half inclined to doubt whether our author has progressed even so far as the "metaphysic" condition of mind, or whether he has yet emerged from that Fetish worship, where reverence is proportionate to the bigness of the idol.

Totally inconsistent with itself—the product of coarse feeling operating in a crude intellect—the boasted fundamental conception of the 'Vestiges' turns out to be unworthy of serious attention, and might be well left to find its own level, were it not that the Vestigiarian has mixed up and confounded together with his supposed explanation of creation, this "creation" in the manner of law, the totally independent idea, which took its origin in far other heads—that the past may be interpreted by the present; and that the succession

of phenomena in past times, took place in a manner analogous to that which occurs at the *present day*. Such a proposition is the base of the modern science of history, whether natural or civil: its truth or falsehood is a perfectly legitimate subject of inquiry, but the result neither increases nor diminishes the "region of marvel."

If with Sir Charles Lyell we affirm that the physical forces at present at work are sufficient to account for the changes undergone by the earth's surface in past ages, we do not render those changes either more or less wonderful than they were before—nor do we in any way account for them—we merely state them in a readily conceivable form.

So, if with the Progressionists, we conceive that species of living beings undergo transmutation at the present day; that this transmutation is from a lower to a higher type; and that all the kinds of living beings which have ever existed upon the earth's surface, have originated in this way; the idea is a perfectly legitimate one, and must be admitted or rejected according to the evidence attainable; but if fully proved, it would not be, in any intelligible sense, an *explanation* of creation; such "creation in the manner of natural law," would, in fact, simply be an orderly miracle.

In truth, every one who possesses the least real knowledge of the methods of science, is perfectly aware that "natural laws" are nothing but an epitome of the observed history of the phenomena of the universe; and to assert that the Creator, from whom these phenomena proceeded, worked in the manner of natural law and that, therefore, there is no scope for wonder, is as if one should say that, in ancient Greece, he worked in the manner of Grote's History, and that, therefore, there is nothing remarkable in Greek civilization—that is to say the phrase is simply ridiculous and unmeaning.

On the other hand, if by the expression, "creation took place in the manner of law," we mean only that the new phenomena were correlated together, or succeeded one another in a manner analogous to that in which certain phenomena are correlated or succeed one another at the present day, if we assert that the civilization of ancient Greece was developed in the same manner as the civilization of a new community at the present day; we have a scientific proposition which is intelligible and is capable of proof or disproof; but the demonstration of the analogy of two sets of phenomena, each of which is marvellous, does not, so far as we know, diminish the marvellousness of either. The production of Goethe and Schiller by German civilization, is analogous to that of Shakespeare and Milton by English civilization; but we do not perceive that the *fact* of the origin in

either case is thereby rendered less wonderful, or in any way explained.

Whether true or false, then, the scientific basis of the 'Vestiges' cannot bear out its speculative conclusions; for the progression theory, if true, would be no explanation of creation. But has the progression theory any real foundation in the facts of palæontology? We believe it has *none*, and for the following reasons.

In the first place, with respect to plants. We must altogether demur to the assumption at p. 54 of the 'Vestiges,' that "the numerous fungi and other lowly forms, could scarcely have left clear memorials of themselves in the rocks, or in the masses of coal." Lichens, at any rate, are hard and indestructible enough, and had there been a "cryptogamic age," in which the flora was composed of fungi, algæ and lichens, we see no reason why the two latter should not have been preserved. But so far from there being reason to believe in the absence of higher plants in the early ages, the fact is, as even the author of the 'Vestiges' admits, at p. 59, that in Portugal, and in America, in the lower Devonian and even in the Silurian—that is, the lowest fossiliferous—rocks, not only ferns, but lepidodendra, which are among the highest cryptogamic forms, have been discovered. Even supposing then that the ludicrous classification of plants, quoted with apparent approbation, italics and all, from an article in the 'Quarterly Review,' by our Vestigiarian,[1] were correct, the first plants would still be the very highest cryptogamia, and not low forms, as they ought to be.

There are two points which should be carefully remembered by every one who would understand the total inefficiency of the progression theory as applied to plants, but which are not mentioned by the Vestigiarian—the first is, that during the carboniferous epoch, ferns existed, so closely resembling those of the present day, that it is doubtful whether they are generically different (Lyell, 'Manual,' p. 310); and secondly, that the lycopodiaceæ and equisetaceæ of those days, were much more highly organised plants than any of their present representatives; so that we can definitely say, as regards the cryptogamia, that since the carboniferous epoch, there has been no advance in some respects, and a very decided falling off in others.

Precisely similar arguments apply to the lowest discovered remains of animals. These have been found in the Llandeilo flags, at the bottom of the Silurian system, and are cystidæ, graptolites, trilobites,

[1] "Now we suppose it will be admitted the Cryptogamia, Phænogamia, Gymnosperms, and Dicotyledonous Angiosperms, *constitute a succession, and a progressive one.*"

and lingulæ—the latter being the oldest and lowest. Lingulæ, however, are anything but the lowest in the scale of organization of their class; they have a well-developed intestine and well developed hearts, a nervous system, and long, peculiarly organized arms. So far from the brachiopoda being, as our author states (p. 199), "the first animals we meet with in this line, having parts capable of commemorating their existence," there lies beneath them, in the zoological scale, the vast series of the polyzoa, the great majority of which possess hard parts, eminently preservable; to say nothing of the tunicata, which the Vestigiarian, guided by his second-handed information, supposes to be unpreservable (ibid.); while, in fact, their integuments are always woody in composition and often so in hardness.

As to the graptolites, the assertion of the Vestigiarian, at p. 34, that they are "a humble polypian family," is untrue. All the evidence that we have leads us to believe, that they were either pennatulidæ—which belong to the more highly-organized helianthoid polypes—or polyzoa, which are higher still. Here, again, the lower forms of polypes, the sertularians, are eminently preservable; so that had they first existed, there would have been no difficulty in finding them; and as if to spite the progressionists, those forms of animal life which lie below them, the sponges and foraminifera, are the most easily preserved of all, from their calcareous spicula and shells; but of these hardly a trace has been found in the lowest strata. This fact is indeed adverted to in the Proofs and Illustrations (p. xii. *et seq.*), where the author, treating of the forms of animals in ascending order, "illustrates" his own geological lore by placing foramenifera (*sic*) *after* polypiaria.

Had the first crustaceans been low forms, we should have had daphnidæ and cypridæ in the Llandeilo flags. What is the fact? The first crustaceans are trilobites, which, there is every reason to believe, resembled the limulus, the highest of the entomostracous crustaceans. However, supposing that the trilobites are very low crustacea, still, in the series of annular animals, annelids are below them, and should have been found earlier. The reverse is the case.

As respects the cystideans, we must remark, that the absence of any living type which at all resembles them, should lead us to be excessively cautious in drawing conclusions as to their real nature, particularly if we consider the very extraordinary facts which Professor Müller's researches have recently revealed to us, with regard to the relation of the adult forms of echinoderms to their larvæ; and which are a sufficient answer to Agassiz's dreams upon this subject, quoted at p. xiii. of the Illustrations. However, the author of the 'Vestiges,' in what he has to say about the crinoids and cystideans, exhibits a

more dense ignorance as to the facts of comparative anatomy than is even usual with him. The crinoidea, says he, "might be compared to a lowly kind of star-fish fixed on the top of a flexible stalk, arising from the sea bottom. . . . . It is a very humble animal, only, indeed, a stomach, with arms wherewith to supply itself with food." We have a sort of notion, on the other hand, that some ten or fifteen years ago, one Johannes Müller—of whom our erudite Vestigiarian may, perhaps, have heard, in the course of his laborious and conscientious zoological studies—wrote a long essay upon the organization of the Pentacrinus Europœus, in which he showed that the crinoids have a spiral intestine, provided with a distinct anus,—thus standing higher than some asteridæ,—a very distinct water-vascular system, with ambulatory feet, and a blood-vascular system. In truth, the crinoids are as highly organized as the asteridæ; and the prevalent notion that they resemble the larval forms of other echinoderms, has been long since upset by the discoveries of Müller, Busch, &c., which demonstrate that all echinoderms, so far from being fixed, are locomotive active swimmers in their youngest stage; and that the larvæ of crinoids (comatula) resemble those of the highest holothuriadæ.

As for the other animals of the lower Silurian period, the Annelids and the Molluscs, the assertion at p. 41, that the palæontology of the lower Silurian period exhibits families, "generally speaking, low in their respective lines of gradation," is as little borne out for them, as for the others to which we have referred. The often-repeated conclusion drawn from the nautilus-like form of the shell of Lituites and other lower Silurian genera, that these were tetrabranciate cephalopods, ceases, as Mr. Austen has well shown, to have much weight, when we consider, that if we did not happen to be acquainted with the animal, the same thing would be (and indeed was) said of Spirula; and again, it is more than probable that the shell of Bellerophon is not that of a pteropod, but of a heteropod, the most highly-organized among the mollusca cephalophora.

Such is the Fauna of the lower Silurian strata. It contains animals which are, to use the weakest phrase, far above the lowest in their respective lines, and of the very lowest classes of animals, sponges, foraminifera, and sertularian polypes—all of which are very easy of preservation—it offers few traces.

The facts which we have stated are notorious; they have been insisted upon by Sir Charles Lyell; they are taught every year by Professor E. Forbes, in his public lectures at the School of Mines; they are denied by no one; and it was, therefore, with a feeling closely allied to disgust that we perused pages 140 and 141 of the

'Vestiges,' in which we find the barefaced assertion, that the doctrine of the progression of animal forms in time, is "only feebly disputed by one or two geologists;" that "it can be asserted, on the authority of the first naturalists of the age, that, in all the conspicuous *orders* of animals, there have been, in the progress of time, strong appearances of a progress of forms, from the more simple to the more complex;" that "the general fact of a progress in all the orders is not to be doubted;" while there is not the slightest reference to the explanation of the appearance of progression in some groups, afforded by the known laws of bathymetrical distribution, so admirably developed by Professor Forbes. It may be, however, that Forbes and Lyell are the "one or two geologists," whose opinions are treated with so much contempt by our Vestigiarian.

The most prominent argument made use of by those advocates of the progression theory, from whom the Vestigiarian derives his information, is drawn from the nature of the palæozoic fishes. Agassiz, the great investigator of these animals, whose lively fancy has done at least as much harm to natural science as his genius has assisted its progress, maintains that the Ganoid and Placoid fishes of the Devonian epoch, represent the embryonic stages of osseous, or, as he calls them, "more perfect" fishes, in their heterocercal tail, cartilaginous skeleton, and more or less persistent chorda dorsalis. The Vestigiarian, who parades Agassiz on all occasions as *the* philosophical naturalist of the day,—a circumstance in itself sufficiently indicative of his own scientific knowledge and judgment,—greedily seizes upon this notion, re-enforcing it in the Proofs and Illustrations of the present edition by the authority of the writer in the 'Quarterly,' from whom he quotes the following passage:

"It is no argument against the views that naturally arise out of the summary of the facts of Palæontology, as they are now known, to urge that 'the fish and reptiles of the secondary rocks are as fully developed in their organization, as those now living.'—*Sir Charles Lyell.*) . . . . One of the leading distinctions amongst animals is the position of the skeleton; the great binary division of Lamarck into vertebrata and invertebrata was based upon this distinction; and Cuvier's supplementary labours, which made us better acquainted with the real nature and value of the invertebrate groups, have served in the main to confirm the reality of the great characteristic manifested in the internal or external positions of the skeleton.

"We have already adverted to the fact, that no completely ossified vertebrata of a fish had been discovered in the strata of the Silurian and Devonian period. Those strata are of enormous extent, and have

been most extensively investigated. As regards the internal skeleton these primeval fishes were less fully developed than those of the tertiary and existing seas.

"[Their external or dermal skeleton] was not only developed in excess, as compared with the great majority of recent fishes, but presented in its form and structure a closer analogy to the exo-skeletons of invertebrata than that of any known fish which possesses the same system of hard parts well calcified. In Pterichthys, Pamphractus, and Coccosteus—e.g., of the Old Red Sandstone rocks of Scotland, the exo-skeleton presents the form of large plates, either symmetrical, or articulated symmetrically by straight sutures, like the shell of the lobster. The large calcified dermal shield which protected the head of the Cephalaspis, has often been mistaken for that of a trilobite of the division Asaphus" (pp. xxiii.—iv.).

All this is ascribed by the Vestigiarian to Professor Owen, but we really must, however unauthorizedly, interpose to save the learned Professor's reputation, and to protect him against the ascription of supposititious writings, with which his known and published opinions are totally at variance. Is it conceivable that a man who ventures to write upon matters of comparative anatomy should be unacquainted with Professor Owen's Hunterian Lectures upon fishes? But the whole of Chapter VI. in that excellent work is devoted to a most successful demonstration of the non-embryonic nature of cartilaginous fishes, and the author speaks, not without some contempt, of the progressionists :

"Yet there are some who would shut out, by easily comprehended ut quite gratuitous systems of progressive transmutation and self-creative forces, the soul-expanding appreciations of the final purposes of the fecund varieties of the animal structures, by which we are drawn nearer to the great First Cause. They see nothing more in this modification of the skeleton, which is so beautifully adapted to the exigencies of the *highest organized of fishes*, than a foreshadowing of the cartilaginous condition of the reptilian embryo in an enormous tadpole, arrested at an incomplete stage of typical development. But they have been deceived by the common name given to the plagiostomous fishes: the animal bases of the shark's skeleton is not cartilage. . . . ."

In like manner the modifications of the dermal skeleton of fishes have been viewed too exclusively in a retrospective relation with the prevalent character of the skeleton of the invertebrate animals" (p. 147.)

And again at p. 148 :

"These teleological interpretations of the dermal bony plates may

give some insight into the habits and conditions of existence of those Ganoid and heavily protected Placoid fishes which so predominated in the earlier periods of animal life in our planet; whereas these Ganoids and Placoids have hitherto been viewed almost exclusively by the light of the analogy of an embryonic 'Age of Fishes,' or explained by the hypothesis of transmuted Crustacea. Some have gone so far as to affirm that in all those solid parts that cover and shield the exterior of the body of the sturgeon and analogous fishes, there is nothing in the least analogous to any part of the internal articulated skeleton of the vertebrata,' but that 'it is entirely a remnant of the superficial shells of the invertebrata.' You would hardly suppose, from these exaggerated expressions, that both Ganoid and Placoid plates are as richly organized and permeated by nutrient vessels as the bones within; and that they present the same microscopic structure as the ossified parts of the endo-skeleton which they serve to protect."

And in addition we find, in the arrangement of fishes "in the ascending series," at p. 47, that the Ganoid fishes are placed *above* the Cycloid and Ctenoid fishes, and the Placoid fishes again *above* them.[1]

We cannot but think that any man who is acquainted with these published opinions of the Hunterian Professor, and can ascribe the article in the 'Quarterly' to him—or, on the other hand, who, not being acquainted with them, can dare to write on the Palæontology of Fishes, must have a superhuman allowance of the "æs triplex" about his conscience;—perhaps, however, as the incognito of the Vestigiarian does away for the necessity of the presence of this "exo-skeleton" in his countenance, the principle of "*balancement*" may account for its over-development in the other region.

Our critical arm, however, is really weary of smiting this straw giant, and it will be some relief to ourselves and our readers to digress for a short space on to the general question of the organization and position of the Ganoid tribes, inasmuch as they seem to us to form the key of the position of both the progressionists and their adversaries.

The arguments of those who maintain the low position of the Ganoid and Placoid fishes of the Palæozoic period, are the following:

(*a*) The imperfect development of their vertebral column, and its non-ossification.

(*b*) The existence of an extensive exo-skeleton.

(*c*) The heterocercal tail.

[1] See, also, Owen, loc. cit., p. 13. "Sharks and rays, called amphibia nantes by Linnæus," in explanation of the phrase "higher fishes," in the text.

(*d*) The tadpole-like appearance of some genera, such as Cephalaspis, &c.; the position of the viscera, anus, &c., in these genera.

(*a*) To say nothing of Professor Owen's argument as to the possible teleological meaning of the comparatively soft state of the vertebral column—of the fact that it is ossified to a very considerable extent in a manner (*loc. cit.*, p. 147) totally different from that of an embryo [1]—and of its histological difference from the embryonic tissue, we find that the amount of cartilage in the vertebræ, or the incompleteness of the ossifying process, *bears no relation whatsoever to the position of the fish in the scale, or to the rest of its organization.* This is, we know, a bold assertion, but the facts are open to every one. If we compare, for instance, the vertebra of a shark with that of a pike or salmon, we shall find the amount of osseous matter and its arrangement to differ very little (see Williamson, *loc. cit.*); while, on the other hand, in the Helmichthydæ—a highly interesting class of fishes, to which Professor Kölliker has lately directed particular attention—the vertebral column contains a complete chorda; and though this is surrounded by flexible thickened portions which represent the bodies of vertebra, these are not true vertebræ, but mere thickened and slightly calcified portions of the sheath of the chorda. But these Helmichthydæ unquestionably belong to the division of the Murœnidæ, and, as Kölliker says, "are osseous fishes, almost without bones, with a chorda extending to the skull, and almost avertebrate."

Again "the skeleton of the Lepidosiren is said by Professor Owen to manifest," upon the whole, the highest grade which is attained in the class of fishes (*loc. cit.* p. 83); but in this very fish the embryonic state of the bodies of the vertebræ as a continuous chondro-gelatinous chord remains, though the neur- and par-apophyses, many cranial bones, and the maxillary, mandibular, hyoidean, and scapular arches are well ossified (*loc. cit.* p. 57). Well worthy of the attention of palæontologists, especially as contrasted with the paragraph from the 'Quarterly,' above quoted, is this important passage, at p. 57 of the same work:

"The fact of many fossil Ganoid fishes showing the same parts of the skeleton petrified and undisturbed, but without a trace of the central elements of the vertebræ, shows *that the transitorial condition of the Lepidosireus skeleton was not uncommon in the primæval*

[1] See Professor Williamson: Structure and Development of Scales and Bones of Fishes. Phil. Trans., 1851.

members of the class. So far as the observations of M. Agassiz have extended, not one of the fossil fishes hitherto discovered in the Silurian and Devonian rocks, the most ancient in which remains of that class have been found, manifest a vertebral centrum; and not many have shown neural and hæmal arches and spines."

Here we have the highest authority for believing that the Lepidosiren is the highest member of its class, that it has an unossified vertebral column, and that the Silurian and Devonian tribes resembled it in this respect. What becomes, then, of the reiterated argument as to the inferiority of the Ganoid fishes, drawn from this very fact?

(*b*) It is amusing to finding writers who argue to the low position of the Ganoid fishes from their resemblance to vertebrate embryos, in the same breath urging the excessive development of the exo-skeleton as confirmatory of their views. Is it not perfectly clear that so far as the Ganoid fishes have an exo-skeleton, they depart from the organization of a vertebrate embryo, and that, therefore, the two trains of reasoning are inconsistent? So far as their exo-skeleton approaches an invertebrate development, to precisely that extent they diverge from embryos, which have no exo-skeleton. But is it true that the Ganoid exo-skeleton in any way approximates that of the invertebrata or that it is more developed than that of osseous fishes? We totally deny either statement. The arrangement of the plates upon a Pterichthys, or Holoptychus, or a Coccosteus, is totally unlike anything articulate—unless that notable analogy brought forward by the author of the article in the 'Quarterly,' that they have straight sutures "like the shell of a lobster" ("an M in Macedon and an M in Monmouth"), is to have any weight; or that still more forcible evidence that somebody has "mistaken" the head of a Cephalaspis for that of an Asaphus. The author of the 'Vestiges' has "mistaken" the pen of the 'Quarterly' reviewer for Professor Owen's—would a sane man take this as evidence of the fact?

In the second place, it is not true that the Ganoid exo-skeleton is either more extensive or better developed than that of osseous fishes, unless mere thickness is to be called better development. It seems to be forgotten that a perch has as complete an osseous covering as any extinct Ganoid fish; every scale being as truly a bony structure as the bones of its endo-skeleton; and that the scales of the Gurard and Trunk and File fishes are as thick and as strong as those of any extinct Ganoid.

(*c*) Similar arguments apply to the heterocercal tail-fin; the Lepidosiren, "the highest fish," has no tail-fin at all: a particular in

which it is exactly resembled by Coccosteus, Pterichthys, and Cephalaspis ; which have been on this ground, among others, relegated to the lowest division. Again, the "Salamandroid Lepidosteus, with its lung-like air bladder," is, among the Ganoid fishes, accounted the highest by reason of the ball and socket structure of its vertebræ, but it has a heterocercal tail ; while the Amia, which has ordinary vertebræ, has the tail homocercal. Surely criteria like these, which can be shown to fail in obvious instances, should hardly be applied to so obscure a subject as Palæontology.

(*d*) Perhaps the most singular mode of proving the inferiority of organization of Cephalaspis, &c., however, is by comparing them to tadpoles of Batrachia (Agassiz). Surely, if this argues anything, it is that they are higher than other fishes. The grounds of the comparison are worth noting ; they are these : the large head, undistinguished from the thorax ; the aggregation of the viscera anteriorly ; the position of the anal fin and vent immediately behind the cephalo-thoracic expansion ; and the appropriation of the rest of the trunk for locomotion. Any one who will go into the market and buy a sole, may satisfy himself that on these grounds that unhappy fish has hitherto been raised beyond his proper position, and is no better than an upstart tadpole ; and the Gymnotus and the Amblyopsis, will no less learn to "begin with shame to take a lower place."

We must hold, then, until altogether new evidence is brought to bear upon the point, that there is no evidence whatever to show that the extinct Ganoid fishes were not as highly organized as the recent Lepidosiren : that the strong presumption is that they *were*, and therefore that so far from resting content with Sir Charles Lyell's modest supposition, that "the fish of the secondary strata are as fully developed in their organization as those now living," we might very reasonably assume that they were *more highly organized*, inasmuch as the Lepidosiren is more highly organized than any other fish.

It may be readily comprehended what validity there is in the whole argument of the 'Vestiges,' as regards the successive development of life upon our planet, when its foundation appears to be thus baseless and rotten. We have submitted this portion of the work to a more detailed criticism, because its positions are maintained by some whose opinions are entitled to respect ; the rest has no such claims upon us, and neither space nor inclination allow us to do more than lay before our readers specimens of a farrago, of whose value they may thence judge. We must remind them that this is the ***tenth*** edition of the book, "with extensive additions and emendations."

The physiology of the Vestigiarian :—

"Nutriment is converted into these (nucleated cells) before being assimilated by the system." (p. 127.)

"The *volvox globator* can hardly be distinguished from the germ which, after passing through a long fœtal progress, becomes a complete mammifer, an animal of the highest class." [!!!] (p. 128.)

"The globules of the blood are reproduced by the expansion of contained granules." [!] (p. 128.)

Pages 133—138 are occupied by all the old nonsense about the Entozoa and Mr. Crosse's Acarus.

At p. 144, it is stated that the mammalia in the fœtal state "have a branchial apparatus. Afterwards this goes back, and the lungs are developed from a different portion of the organism." The bronchial clefts are here absurdly mistaken for a branchial apparatus.

Page 145. "Amongst phanerogamous plants, a certain number of organs are always present, either in a developed or rudimentary state." [!] We should be glad to be informed in the next edition what these organs are, and what their number.

At page 166, the Vestigiarian quotes Dr. Carpenter, to the effect that each germ must have a certain peculiar definite capacity of development, and makes the following sapient commentary :

"I would venture to remark that, without seeing the germ of a particular being maintain in the tendency to the parental form in the nidus of an animal specifically different from its parent, we are not entitled to assume that it has 'a certain capacity of development peculiar to itself.' Its capacity of development may be quite indefinite, and only bound down to the attainment of the parental form by being kept and nourished by the parent." (p. 166.)

Has this profound naturalist ever heard of a cuckoo, or of an ichneumon fly?

The knowledge of the Literature of the subject possessed by the Vestigiarian.

At page 147 we are told :

"Embryonic Development, first surmised by the illustrious Harvey, afterwards illustrated by Hunter in his wonderful collection at the Royal College of Surgeons, Embryonic Development has latterly become a science in the hands of Tiedemann, St. Hilaire, and Serres."

If the Vestigiarian had ever read a page of Harvey, he would find him quoting his predecessor, Fabricius, who like himself by no means "surmised," but worked out development in the chick. No mention of Wolff, or Von Baer!

At p. 171, the theory of the Alternation of Generations, one of the

best established and most notorious scientific generalizations of the day, is talked of as a "late curious investigation by a Danish naturalist;" and we are told, patronizingly, that "Such matters are as yet obscure, however highly they may promise in time to illustrate this question." This ignorance is the more unpardonable, as though the author of the 'Vestiges' is totally unacquainted with foreign literature, the perusal of Professor Owen's 'Parthenogenesis,' published years ago, would have been amply sufficient to give him more just ideas. But we suppose it was pleasanter to generalize than to learn.

The comparative Anatomy of the Author of the 'Vestiges'.—

"The Tunicata are similar in all essential respects [to the Brachiopoda and Lamellibranchiata] except in being of humbler organization." [!] (p. 199.)

"Between the invertebrate animals and the fishes, the junction is tolerably clear at one point. This is where the cephalopodous mollusks connect with such fishes as the myxine or hag, and the lamprey. . . . . *The affinity to the cephalopods is fully admitted.* It is seen in the nature of the skeleton, in the character of the investing skin which ejects a copious secretion whenever the animal considers itself in danger, in the power of respiring through the gill apertures without any dependence for that function on the mouth, and in the eight free filaments seen in some species extending forward from around the mouth." (p. 208.)

This choice morsel of zoological reasoning may be left to itself, especially as a few lines further on, we have the old nonsense about the cephalopod being a vertebrate folded upon itself (which was exposed and set aside twenty years ago by Cuvier) formally reproduced. The assertion which we have signalized by italics is quite an effort of genius as a piece of effrontery.

At p. 210, the humbler forms of fish are said to approach the annelides, which is equally untrue; and a little further on we find it said that the fistularidæ approximate the vertebrata. [!]

Surely we have waded far enough through this lumber-room of second-hand scientific furniture, this attempt to build a tower of Babel heaven-high with half-burnt bricks; at any rate, far enough to convince the reader that however the Vestigiarian may wince under the remark, Professor Sedgwick was quite justified in asserting that he is "not only unacquainted with the severe lessons of inductive knowledge, but possesses a mind apparently incapable of comprehending them."

We look for evidence of knowledge, and we find—what might be picked up by reading 'Chambers's Journal' or the 'Penny Magazine.'

We look for original research, and we find reason to doubt if the author ever performed an experiment or made an observation in any one branch of science. We seek for acuteness of thought, and we find nothing but confusion of ideas, and an ignorance of the first outlines of speculation. A spurious, glib eloquence, an affectation of reverence for truth and of scientific modesty, are not wanting to remind the curious observer all the more strongly of the total absence of that careful research and fair representation of both sides of a question, which should be the first-fruits of the latter qualities.

The author of the 'Vestiges' plumes himself greatly, and is much praised by others, for the calm and philosophic style of his book; and he complains bitterly of the opposite tone adopted by certain of his reviewers, especially by Professor Sedgwick. The handling of the Woodwardian Professor may have been a little more rough than should beseem a Cambridge Don; but to a thorough, an earnest, and above all, a genial man, who has made truth the search of his life, and knows the difficulties of the road and the stern practical discipline required for success—to such a man, a Hotspur resting after the extreme toil of the fight, there is a source of wrath, such as the author of the 'Vestiges' is obviously quite unable to understand, in the cool interposition of a mere sciolist with his "hypotheses" in a neat pouncet box, who would have been an astronomer—but for sitting up at night; a geologist—but for soiling his fingers; a physiologist—save for "the dirty and unhandsome corses;" attempting to divide the spoil he was incompetent to win, and cutting his fingers with the weapon he is unable to handle.

But truly, as a man sensitive to criticism, and particular about the preservation of his own incognito, our Vestigiarian conducts himself somewhat oddly. In a note (p. lix., Appendix) to the present edition, forgetting the garb of meekness assumed throughout the text, he ventures to sneer at Professor Sedgwick and the "mechanical department of the one science in which his name has a place," and at Dr. Clark, of Cambridge. It is needless to justify the reputation of either of these gentlemen against such attacks; but we dare venture to predict, that should the author of the 'Vestiges' ever be so ill advised as to let his name be known, it will be found prominent neither in the mechanical nor any other department of even *one* science —unless the science of a Mechanics' Institute, which is about the calibre of our author's, is to be called a mechanical department of science. And however proud our Vestigiarian may be of his notoriety, we may remind him, that had Dr. Clark, of Cambridge, whose extensive knowledge and sound judgment are well known,

been so misguided as to write the 'Vestiges' in his student days (as any sharp, careless lad might), he would simply have burnt it subsequently; and yet, though he had thereby escaped being known 'outside the walls of Cambridge,' his scientific reputation, in the mind of every one conversant with these matters, would have stood incomparably higher than if he had published it. Any man of science of ordinary judgment has considered and rejected the notions which the author of the 'Vestiges' advances as great facts.

Not less remarkable than the infelicitousness of his sarcasm is the want of knowledge of the etiquette usual among authors displayed by this unfortunate scientific *parvenu*. An article which appeared in the 'Quarterly,' and to which we have already made frequent reference, is repeatedly quoted, and attributed to Professor Owen, obviously without authority. In any case the attribution of anonymous writings without very good grounds is a proceeding in very questionable taste, and in the present instance it is particularly so; for, to say nothing of that wonderful classification of plants into Cryptogamia, Phænogamia, Gymnosperms, and Dicotyledonous Angiosperms which the Hunterian Professor must feel truly gratified to have laid to his account, the paper in question contains a most unjust and unworthy reference to a gentleman whose scientific zeal, extensive information and kindly readiness in communicating it, have won him the good-will and respect of every one but the writer of that article—we mean Professor Quekett. To ascribe to that gentleman's nearest colleague this underhanded attack upon him, is a most marvellous *bêtise*, not less remarkable than the critical sagacity which would fain make Professor Owen express opinions which are in direct contradiction, as we have shown, to his published works.

In conclusion we cannot address to our Vestigiarian a peroration so condescendingly benevolent as that with which he leaves Professor Sedgwick, (Proofs, lix.) We do *not* "part with him in perfect good humour," but in a very bad humour. We desire too much to have some value set upon our praise, not to speak boldly where great demerit calls loudly for censure. In the popular mind the foolish fancies of the 'Vestiges' are confounded with science, to the incalculable diminution of that reverence in which true philosophy should be held; and we should be unjust to our readers, and false to our own belief, if we commented upon them in any terms but those of the most unmitigated reprobation.

II

BRITISH FOSSILS

ILLUSTRATIONS OF THE STRUCTURE OF THE CROSSOPTERYGIAN GANOIDS[1]

Memoirs of the Geological Survey of the United Kingdom. Decade XII. 1866.

I.—THE GENUS GLYPTOPOMUS.

AT p. 57 of the "Poissons Fossiles du Vieux Grès Rouge," Prof. Agassiz remarks, in establishing this genus, that he at first took the only specimen known to him for a *Platygnathus*; and it is figured in the 26th plate as *Platygnathus minor*. He describes the unique specimen of *Glyptopomus minor* in the following terms:—

"This fish, of which I know but a single specimen, obtained at Dura Den, and placed in the collection of Prof. Jameson, has the body wide and heavy, and resembling in form that of *Holoptychius*. It lies on its belly, and is turned a little to the left side, so that it is the back and right side which are visible. The head is proportionably small, and composed of enamelled and irregularly sculptured bones, which appear to be covered with a thick and very variable granulation. In the middle of the head it is easy to distinguish the frontals; in front, the nasals; behind, the occipital; and a great lateral enamelled plate, which indicates that the cheek was covered, as in *Polypterus*, by a single osseous lamella, below which the great masticatory muscle was fixed.

"The scales of the body are very considerable, very high on the sides, almost square on the back. They form oblique series, which meet at an acute angle in the middle line of the back. The scales themselves are very thick, placed side by side, apparently connected together only by the integument in which they were implanted. Their enamelled surface is not smooth, but adorned with a fine granulation,

[1] The earlier memoirs of which this and the next are continuations will be found as Nos. XXIII., XXIV., and XXV. in Vol. II. of the present work.—E. R. L.

which gives them a velvety aspect. I have been unable to examine their microscopic structure.

"Only a few traces of fins are preserved in the specimen figured; probably a portion of the ventral near the throat, and a vestige of the dorsal, or caudal, near the end of the tail. The fin rays seem to have been short and delicate."

In the "Preliminary Essay" of the "Tenth Decade" I described and gave a woodcut of the skull (Fig. 2, p. 422, Vol. II.), represented in Plate I. [Plate I.], fig. 2, of the present decade; and in a note at the end of that Essay, I briefly adverted to the addition made to our knowledge of the genus by the specimen received from Dr. Taylor of Elgin, which I now proceed to describe at length.

GLYPTOPOMUS MINOR. (Plate. I., [Plate 1] fig. 1.)

This is a cast, in tolerably fine-grained sandstone, of an entire specimen of *Glyptopomus*, the parts of which have undergone very little derangement. The sandstone block in which the fish has been preserved is split into two slabs, along the plane traversing the body of the fish, and, in general, midway between its dorsal and ventral surfaces. The one slab (Plate. I. [Plate 1], fig. 1) therefore, contains, for the most part, the impression of the dorsal surface of the fish, while the other exhibits the impression of its ventral surface; but the plane of splitting has not traversed the head, so that the impression of the jugular plates and lower jaw is left on both slabs. On the one, or dorsal slab, however, it is the impress of the inner surface of the bone of these parts which is shown, while, on the other, the outer or sculptured surface has left its mark.

The total length of the body of this fish is 13¾ inches; it attains its greatest width (2¾ inches) in the middle of its length. Some allowance must be made, however, for the compression to which the fish has been subjected.

The greatest length of the head, measured in the middle line, from the anterior end of the snout to the level of the posterior margins of the opercular apparatus, is 2¾ inches, or about one-fifth the length of the body.

The principal jugular plates (*G*) are each two inches long by about three-quarters of an inch wide at widest. The impression of their surfaces shows that they had had a finely-ridged, more or less granular, sculpture. There is no median jugular plate, and there is no positive evidence of the existence of any lateral jugular plates.

Behind, and partially overlapped by, the two principal jugular

plates there is evidence of two triangular sculptured plates belonging to the pectoral arch; and behind these commence the series of ventral scales, which are irregularly four-sided, about a quarter of an inch wide by one-sixth of an inch long, and are disposed in transverse rows which converge obliquely from above and without, downwards and inwards, to the middle line. The surface of the cast of each scale exhibits a multitude of minute hemispherical elevations, corresponding with the pits which constitute the well-known ornamentation of the scales of this genus.

The median dorsal scales are irregularly hexagonal, and the rows of lateral dorsal scales run from them as a centre, downwards and backwards, on each side, to pass into the lateral ventral series. The most anterior and largest of the median scales are as much as four-tenths of an inch wide by a quarter of an inch in length.

The general character of the sculpture is the same on the dorsal as on the ventral scales. On the right side of the body some few of the scales in the position of the lateral line exhibit a grooved character, which is somewhat more prominent in the figure than it appears to my eye to be in nature.

The impression of the anterior dorsal fin (*D*) commences at seven inches and three-tenths from the anterior extremity of the muzzle; that of the second dorsal (D^1) at about nine inches and a half from the same point.

The fin rays of the ventrals (*V*) are visible on one side in the dorsal impression (fig. 1), and, on both sides, in the ventral cast, just in front of the second dorsal. They seem to have been broad, but far shorter than the pectorals, and the impressions are so indistinct that I cannot say whether they are lobate or not.

The pectoral fins (P, $P_,$) are exquisitely displayed; each has a broad scaly lobe, subacute at the extremity, and more than an inch long, by half an inch wide. The scales exhibit the same sculpture as those on the body, but are much smaller, and diminish in size towards the apex of the lobe. The many-jointed fin rays are attached all round the margins of the lobe, and become longer towards its apex, where they form fully half of the length of the fin.

I see no trace of the anal fin in either slab. The impression of the well-defined upper lobe of the caudal (*C*) commences at eleven inches and a quarter from the anterior extremity of the muzzle. The lower lobe is not well shown in either slab; but I suspect from the size of the upper, that the tail is diphycercal.

The only tooth of *Glyptopomus* I have seen, fig. 4, is stout, conical, slightly curved, and deeply grooved longitudinally.

The jugular plates and the mandibles have a coarsely pitted and ridged sculpture (Plate. I., [Plate 1] fig. 3).

These facts leave no doubt as to the position of *Glyptopomus* in the Glyptodipterine family of the suborder *Crossopterygidæ* among the *Ganoidei*.

II.—ILLUSTRATIONS OF THE STRUCTURE CŒLACANTHINI.

I. *The genera* CŒLACANTHUS *and* UNDINA.

In the "Preliminary Essay upon the Systematic Arrangement of the Fishes of the Devonian Epoch," prefixed to the tenth decade of the "Figures and Descriptions illustrating British Organic Remains" (1861), I have endeavoured to prove that the genera *Cœlacanthus*, *Undina*, and *Macropoma*, constitute a very distinct family of the Crossopterygian Ganoids, to which the term *Cœlacanthini* ought to be restricted.

At the time of the publication of this essay I was unaware that, in 1858, the late eminent paleontologist, M. Thiollière, had enunciated the same conclusion in the following terms :—

La famille des Célacanthes comprendrait, à la fois, suivant son auteur, les *Sudis* de la faune actuelle le *Glyptolepis leptopterus* du vieux grès rouge, et le *Cœlacanthus, granulosus* du terrain permain. Ce sont pourtant là trois types ichthyologiques beaucoup trop différents pour être ainsi réunis. Mais, si l'on exclut les deux premiers et qu'on associe au genre *Cœlacanthus*, lui-même les *Macropoma* de la craie et les *Undina*, du Jura, on obtiendra le noyau d'une famille réellement naturelle, et que, pour éviter la confusion, M. Thiollière désignera par le nom d'*Ortho-célacanthus*." [1]

It is to be regretted that only the abstract of this paper has been published, as it would have been very interesting to learn the grounds upon which M. Thiollière's conclusion is based, and which are not stated in the "Note" whence the foregoing passage is extracted.

My own view of the common characters of these genera is given in the following definition of the suborder *Crossopterygidæ* and family *Cœlacanthini* ("Preliminary Essay," p. 26).

Suborder CROSSOPTERYGIDÆ.

Dorsal fins two, or if single multifid or very long ; the pectoral and, usually, the ventral fins lobate ; no branchiostegal rays, but two

[1] *Note sur les poissons fossiles du Bugey, et sur l'application de la Méthode de Cuvier à leur classement ;* par M. Thiollière. Printed in abstract in the "Bulletin de la Société Géologique de France," Sc. 2. I. xv., pp. 782–793, 1858.

principal, with sometimes lateral and median, jugular plates situated between the rami of the mandible; caudal fin diphycercal or heterocercal; scales cycloid or rhomboid, smooth or sculptured.

Fam. CŒLACANTHINI.

Dorsal fins two, each supported by a single interspinous bone; paired fins obtusely lobate; air-bladder ossified.

Since 1861 I have studied a considerable number of specimens of Cœlacanthines belonging to the genera *Cœlacanthus* and *Macropomo*, without finding any reason to modify the definitions just given; but the materials which have passed through my hands enable me to illustrate the structure of these genera more fully than has hitherto been possible

I commence these illustrations with the genus *Cœlacanthus*, for the opportunity of examining numerous specimens of which I am indebted to the Earl of Enniskillen, Sir Philip Grey Egerton, Bart., Dr. Rankine, of Carluke, Edward Binney, Esq., F.R.S., of Manchester, Dr. Garner, and Messrs. Molyneux, Ward, and Weston.

The Genus CŒLACANTHUS, Agassiz.

The name *Cœlacanthus* was first applied to a genus of fossil fishes by Agassiz, in the feuilleton of his "Recherches sur les Poissons fossiles," dated March 1836[1]; and figures of the fragments from the Magnesian Limestone of Durham, to which he applied the title of *Cœlacanthus granulatus*, were published in 1839, in Plate 62 of the second volume of that work.

Furthermore, in the systematic catalogue of the fossil fishes in the collections of Lord Enniskillen and Sir Philip Egerton, the family *Célacanthes* had been established for the genera *Cœlacanthus Holoptychius* and *Macropoma*, with two additional species of *Cœlacanthus*, *C. lepturus* and *C. gracilis*, from the Carboniferous formation.

But no description of these specimens, or diagnoses of the genera, had appeared in 1842, when Count Münster published the fifth part of his "Beiträge zur Petrefacten-Kunde," containing figures and descriptions of the fishes from the Lithographic slates which he names *Cœlacanthus striolaris* and *C. Köhleri*.

Count Münster, however, had already published notices of these fishes in Bronn's "Jahrbuch," for 1842, and had applied the generic title of *Undina* to them. And he remarks, that if Agassiz's genus *Cœlacanthus* from the older formations is provided, like *Macropoma*,

[1] *See* Count Münster's "Beiträge" Heft, V. 1842.

with conical teeth, the otherwise very similar fishes from the Lithographic slates would belong to a different genus, for which the title of *Undina* might be retained.

With this proviso Münster continues his description, as follows :—

"Genus CŒLACANTHUS, Agassiz.[1]

"Teeth flat, strongly granulated: scales thin, elongated, rounded off: two dorsal fins: caudal fin very large and broad, vertebral column traversing the middle of it, and forming at its point a second small pencil-like fin. Skeleton, with the exception of the vertebral column, bony; body elongated.

"1. *Cœlacanthus striolaris* . . . .
I am acquainted with four specimens of this species, all of which were found at Kelheim, on the right bank of the Danube. The largest of them in my collection, measures a foot (Rhenish) from the head to the tip of the tail, and three inches five lines in breadth, without the fins; the smallest specimen, in which the apex of the head is wanting, is nine inches long and two inches six lines broad. The former is depicted in the second plate, but, since the thoracic and abdominal fins are not well preserved in the original, I have supplied these parts in the figure from other specimens. Both specimens, as well as a third which I have had the opportunity of examining, lie upon one side, and exhibit a slightly convex back and an almost straight ventral line. The head is small, the forehead strongly arched; the bones of the head, however, are very brittle, and hence are badly preserved. Of the teeth only a few, as well in the upper as in the lower jaw, are visible, and are seen, above, from the side, below, from the upper surface. Whether more than one series exists is not clearly discernible. The most distinct are a few teeth of the lower jaw, which are represented magnified in figure 8, have an angular flat form, and are strongly granular upon their upper surface; within these teeth, a few others which were more rounded off appear to have been implanted in the lower jaw. The bone of the jaw however, is so brittle that no more exact determination of this point can be made.

"The scales are relatively large, but so thin and so closely united together, that in a few spots, especially towards and amidst the caudal fin, they appear like a finely-striated membrane. . . . . .

"They all exhibit fine, short, elevated ridges, and only the cervical scales are somewhat granular at their external ends. But the peculiar fins most especially characterize this fish.

[1] The references to the figures are, for the most part, omitted in this translation.

"The first of the two dorsal fins, which lies over the pectoral fin, has eight simple rays, which in their proximal halves, are deeply grooved, thick, and crenulated on the outer edge; on the upper side, towards the point, however, they are flat and closely jointed. The second dorsal fin has 13 or 14 flat, closely-jointed, rays, somewhat depressed in their middle part and grooved towards the root. This fin is placed directly over the anal fin, which has a perfectly similar size and composition. Fig. 14 depicts one of the median rays. The ventral fin is small, but indistinct and weathered. The pectoral fin has 13 or 14 flat closely-articulated rays, just like the two dorsal and the ventral fins. Most remarkable, however, is the broad caudal fin, which is divided by the unossified vertebral column into two halves, the upper of which bears 20–21 rays, the lower 18–19, which form prolongations of the vertebral processes. The outer side of the deeply-grooved rays is very finely notched, almost toothed; the thick spinal column forms, at the end of the two caudal fins, a pointed pencil-like second caudal fin, with 20 or 30 short, flat closely-jointed rays. The unossified spinal column is finely striated; in the middle of it very short bones in pairs appear. The spinous processes are continued along the whole dorsum of the spinal column. Neither ribs nor special bodies of vertebræ are visible. In these specimens the stomach of the fish is rendered obvious by a depression, with a smooth shell-like investment, like what may be seen in most specimens of *Macropoma Mantelli.*

"2. *Cœlacanthus Kohleri.* . . . . . .

"I know of only one imperfect specimen of this species, for which I am indebted to the kindness of M. Kohler. The greatest part of the head, with the pectoral and ventral fin of this individual, are wanting. It was at least one-third larger than the largest specimen of the preceding species, from which it is especially distinguished by its scales which are covered with raised elongated points, almost like flies' eggs. The few scales whose external form is recognizable, resemble those of the preceding species, but are larger, and have elongated granulations upon their surface.

"The fins closely resemble those of the foregoing species. The first dorsal has nine thick rays, which are very long, and are distinguished from those of the preceding species by the rows of small spines which beset their outer sides as far as the middle. . . . . The point is flat and closely articulated.

"The second dorsal has 19 or 20 very broad, sharp-pointed rays, which are so close together that they come into contract in the middle

"The anal fin is constructed like the preceding.

"The broad caudal fin is distinguished from that of the preceding species by a greater number of rays, and especially by many series of small spines on the outer side of the rays, as fig. 17 shows. In this species also the stomach with its smooth coat is visible'

Another species of *Cœlacanthus*, from the Kupferschiefer of Richelsdorf, is described by Count Münster, at p. 49 of the same part of his "Beiträge," under the name of *Cœlacanthus Hassiæ*. Though only a damaged skeleton without scales, it agrees closely, in general form as well as in its essential details, with *Cœlacanthus striolaris*.

The teeth are not recognizable. A few large scales lie scattered about. They are very large, but so thin that their proper form is not clearly distinguishable. However, they are all rounded off, smooth, raised from the exterior towards the middle, and correspondingly depressed below.

The anterior dorsal fin possesses ten very long, strong, simple rays, which are somewhat crenulated on the outer side, and jointed towards their end. The second dorsal fin has much finer articulated rays. The great ventral fin has long laterally crenulated rays; the vertebral column is unossified; the spinous processes of the vertebræ are only to be seen distinctly on the dorsal side of the vertebral column, and increase in size towards the tail.

It is clear from these descriptions that Count Münster was the first to indicate and define most of the great features of the organization of the Cœlacanthines, viz., the unossified vertebral column; the absent ribs; the shelly-walled internal organ, "like that of *Macropoma*"; the well-ossified head; the two dorsal fins; and the remarkable tail, with the singular characters of the fin rays.

Professor Agassiz first published his views respecting the Cœlacanths in 1843, when the second part of the second volume of the "Recherches sur les Poissons Fossiles" appeared.

In treating of the "Family of the Cœlacanths," he writes, at p. 168 of his work, as follows:

"THE FAMILY OF THE CŒLACANTHS.

"I unite in this family many genera of an altogether peculiar physiognomy, but with whose true affinities I am, as yet, only very imperfectly acquainted. A remarkable peculiarity which has struck me in most of these fish, is the circumstance that their bones, and notably their fin rays, are all hollow internally, a peculiarity which is not met with in other ganoids, and which is the origin of the name "Cœlacanth" which has been conferred on the family. This character is especially

striking is the true genus *Cœlacanthus*. To this singular structure of the bones is added another more apparent and more external character, viz., the form and disposition of the fins, and the mode of articulation of the rays; and, in the first place, most of the rays are stiff, or only articulated at their ends. Their combination with the apophyses [neural arches and spines] and inter-apophysial [inter-spinous] bones, is very singular, especially in the caudal fin, the rays of which are supported by inter-spinous bones; an arrangement, which, in other fishes, is found ordinarily only in the anal and the dorsal [*caudale* in the text]. Lastly, the vertebral column is prolonged more or less distinctly, between the principal lobes of the caudal fin, so as to form a median taper process."

Professor Agassiz then adverts to the resemblances and differences between *Cœlacanthus* and *Macropoma*, in a passage which I shall cite hereafter, and proceeds:

"Taking into account the extraordinary development of the dentary system in some genera of this family, and particularly in *Holoptychius*, one is tempted to approximate the Cœlacanths to the Sauroids; whilst the dentition of the genus *Undina*, as it has been described by Prof. Münster, would seem to establish a closer affinity with the Pycnodonts. On the other hand, the scales exhibit peculiarities which are to be met with in no other family, whence I have been disposed to arrange the Cœlacanths provisionally between the Sauroids and the Pycnodonts. It may be however, that their true place is near the Sclerodorms, or the *Accipenseridæ*."

Of the genus *Cœlacanthus* itself, Professor Agassiz remarks (p. 170):

"This genus, which I regard as the type of the family, was long known to me only by fragments; but these were so different from most other ichthyolites, that I did not hesitate to form them into a distinct genus. What especially struck me was the form and the structure of the fins, their relation with the interspinous bones, and the manner in which the apophyses [vertebral arches and spines] are united on the one hand with the bodies of the vertebræ, and on the other with the interapophysial [interspinous] bones. The apophyses divide at their bases into two branches, forming a fork, which embraces the body of the vertebra; to this apophysis succeeds an ossicle, which, instead of being interposed between two apophyses, is fitted on to the end of one, so as to form its direct prolongation. The ray property so called, the longest of the three pieces, is also forked at its base; its extremity alone is jointed, but never bifurcated. These three pieces, the apophysis, the inter-apophysial bone, and the

ray, are about equal in length, and are all three hollow. . . . . . . This singular structure characterises most of the rays which lie at the posterior part of the body; now as, usually, only the anal and the dorsal have inter-apophysial bones, I at first concluded that these two fins must be excessively developed; and what helped to strengthen me in this idea, was the fact that the vertebral column appeared to be continued beyond the two azgyos fins, to form, further on, a bundle of very small articulated rays, attached directly to the vertebræ. But Lord Enniskillen's discovery of an entire specimen of this remarkable type has completely modified my views. It now appears that besides the fins of so exceptional a structure, which I regarded as anal and dorsal, this fish has a very distinct normal anal and two dorsals. Now unless the existence of three dorsal and two anal fins of very different structure—an arrangement which occurs in no known genus of fishes—be admitted, it is necessary to regard the terminal fin of the body as a caudal. For the rest, this is not the only known example of a caudal supported by inter-apophysial bones, the caudal of *Polypterus bichir* being supported by similar bones, at least its upper lobe. What is truly exceptional is the prolongation of the tail beyond these rays, and the little fascicle of articulated rays surrounding its extremity. In this respect my genus *Cœlacanthus* very nearly approaches the type of a fish from the Lithographic limestone of Kehlheim, for which Count Münster has proposed the generic name of *Undina*. But notwithstanding this analogy, and the altogether similar disposition of the other fins, the fish in question is distinguished by many peculiarities which do not permit it to be confounded with *Cœlacanthus*. The most important difference is presented by the dentition. The genus *Undina* has, according to Münster, pavement-like teeth, very similar to those of certain Pycnodonts. *Cœlacanthus*, on the other hand, has conical teeth, like the Sauroids, and everything leads to the belief that it is a carnivorous fish, so that, far from belonging to the same genus, it is doubtful whether it belongs to the same family. Leaving the caudal aside, the other fins of the genus *Cœlacanthus* present a very simple structure, composed of slender but not dichotomous rays. The first dorsal corresponds to the extremity of the pectorals. The second is opposite the space between the ventrals and the anal. The anal itself is very closely approximated to the caudal. This last fin (comprising in it the bundle of articulated rays which fringes the extremity of the vertebral column) nearly equals one-third of the total length of the fish. The vertebræ are much higher than they are long towards the anterior part of the trunk, but they become sensibly elongated posteriorly. It is the same with the

apophyses, which, very slender in the abdominal region, take on a much greater development in the caudal region. The scales, to judge by the fragment of *C. granulosus*, are large, elongated, and have their posterior edge rounded. I have not been able to ascertain whether they are enamelled or not, but the fact that they are found in strata older than the Jura leads me to suppose that, as in all the fishes of that age, they were enamelled. Their extreme thinness, no doubt, has made them too fragile to be often preserved. I conclude from this description that the genus *Cœlacanthus*, although near the genus *Undina* of Count Münster, is nevertheless different from it, and that the latter should therefore form a separate type in the Cœlacanth family. Consequently it will be necessary to exclude from *Cœlacanthus*, and to place in *Undina*, the remarkable species which Count Münster has described and figured in the fifth part of his "Beiträge," under the names of *Cœlacanthus striolaris* and *Kölheri*. The true genus *Cœlacanthus* is at present restricted to the coal, the Zechstein and the Muschelkalk. I am acquainted with six species.

"*Cœlacanthus Granulosus*, Agass. (Vol. 2, Tab. 62.)

"The species to which I give this name was for a long time the only one known, and the two fragments which are figured were the only representatives of this remarkable family. Both represent the posterior part of a fish of very large size, which, to judge by the relative position of its fins, ought to have been at least two feet long . . . . . . As a general rule the apophyses (neural spines and arches) and the inter-apophysial bones are equal in length. The rays, on the other hand, are a little longer, but they are never jointed down to their bases. The cleft of the ray into which the point of the inter-apophysial bone is inserted is much narrower than that of the apophysis (neural arch), which embraces the vertebral column. It is probable, from all I have been able to see, that, in reality, these anomalous rays are composed of filaments [*filets*], as in most other fishes, only these filaments do not become separate. The rays at the extremity of the caudal fin are exceptions to the general rule, inasmuch as they are directly attached to the vertebral column, without being borne either by an apophysis, or an inter-apophysial bone. They are articulated, and appear to be divided at their apices. It is these little rays which I considered, at first, to belong to the true caudal fin. I have explained above, in speaking of the genus, the reasons which have led me to withdraw this opinion, when I had the good fortune to discover a complete specimen of the type in the collection of Lord Enniskillen. Thanks to this discovery, I have been

able to investigate the form of the vertebræ, which I found very massive, like the rest of the vertebral column. It has also led me to consider as a caudal fin all that great fin, borne by inter-apophysial bones, above and below the extremity of the tail; and, as an anal, the simple fin which precedes them below. The anal is composed of much more delicate rays, which, however, equally possess the peculiarity of being bifurcated and articulated only at their ends. The anterior ones are completely undivided.

"The granular spots observable here and there on our specimens are remains of the integument. I have seen fragments of scales only in a portion of another species of Cœlacanth, and from their structure I do not doubt that our *Cœlacanthus granulosus* was covered with similar scales. They are very delicate, and the concentric rings are very readily distinguished in them. The raised granulations which ornament their surface have originated the name *C. granulosus*, which I have given to this species.

"It was found in the Magnesiam limestone of East Hickley, and the originals of the plate are in M. Witham's collection.

"The species the description of which I reserve for the future, are—

"1°. *Cœlacanthus Phillipsii*, Agass. The caudal is more rounded than in *C. granulosus*, its rays are more close set and jointed nearer to their (proximal) ends. The apophyses of the caudal vertebræ are very long and delicate. The scales are large, and rounded posteriorly. From the Carboniferous rocks of Halifax.

"2°. *Cœlacanthus minor*, Agass. A very small species, remarkable for its very short inter-apophysial bones. The joints of the rays, properly so called, are longer than wide. The whole caudal is scarcely more than an inch long. From the Muschelkalk of Luneville.

"3°. *Cœlacanthus gracilis*, Agass. A species of unknown origin, distinguished, by its elongated form; the pedicle of the tail, in particular, tapers evenly [*est tout d'une venae*], and its rays are less close set than in the other species.

"4°. *Cœlacanthus lepturus*, Agass. From the coal of Leeds. This species is still smaller than *C. minor*; its scales have rugose surfaces.

"5°. *Cœlacanthus Münsteri*, Agass. A beautiful species from the coal of Lebach, discovered by Lord Enniskillen, and characterised by its heavy form. It is in this species that I first saw the conical and hooked teeth of the genus *Cœlacanthus*."

The ascription of ossified vertebræ to *Cœlacanthus* is certainly erroneous, and in the "Preliminary Essay" (l. c. p. 16), I have already given the reasons which lead me to demur to Professor Agassiz's views regarding the systematic position and affinities of the Cœlacanths.

Furthermore I have shown that "*Cœlacanthus*" *Münsteri* is not a *Cœlacanthus*; and, consequently, that so far as the arguments in favour of an essential difference between the dentition of *Undina* and *Cœlacanthus* are based upon the dentition of that fish, they are untenable.

In Professor King's "Monograph of the Permian Fossils" (1850), Sir Philip Egerton describes and figures a specimen of *Cœlacanthus granulatus* in his own collection.

"It shows little more of the fish than the figures given by Agassiz; but the scales are in a better state of preservation; they are irregularly rounded, and marked by fine undulating concentric lines. The enamel is thickly covered with the granulations which suggested the specific name. The second dorsal fin is also shown; it seems to have been larger and the rays thicker than in the anal fin opposed to it. The extremity of the tail is dislocated, and is seen in the lower part of the plate," p. 235.

The next page of the work cited contains the description of—

"*Cœlacanthus caudalis.*

"There is a charming little specimen, in the possession of Lord Enniskillen, of a Cœlacanth, which I am inclined to think can scarcely be referred to the preceding species. The entire length does not equal that of the tail of the smallest specimen of *Cœlacanthus granulatus* I have seen. The latter species is supposed by Agassiz to have been two feet in length; this fish measures only five inches. The head is rather more than a fifth of the total length; the second fifth includes the first dorsal, a third fifth extends to the back of the second dorsal, and from thence to the end of tail, occupies the two remaining fifths. This large proportion of the caudal region inclines me to adopt the specific name given above. The body is slender and of uniform size. The first dorsal fin is composed of about eight strong rays; these are carried upon thick inter-apophyses: and the corresponding neurapophysial elements of the vertebræ are enlarged to support them. The same arrangement is seen in the second dorsal, but the fin rays are more slender and more numerous. The pectoral, ventral, and anal fins are of moderate dimensions and slender structure. The tail is broader, and terminates more abruptly, than that organ in *Cœlacanthus granulatus.*"

The only other description of Cœlacanths (other than *Macropoma*) of which I have any knowledge, are contained in the following brief notes upon Carboniferous fishes of the United States, entitled "Description of several new genera and species of Fossil Fish from

the Carboniferous Strata of Ohio," by Dr. Newberry, contained in the "Proceedings of the Academy of Natural Sciences of Philadelphia," vol. viii. p. 98, 1854.

"CŒLACANTHUS, Agass.

"1. C. ROBUSTUS, Newb. Body robust, 1 foot 6 inches in length; upper surface of cranium covered with small closely-approximated tubercles, maxillaries and opercula threaded with fine parallel, sometimes interrupted, lines. Margin of opercula in nature specimens wavy.

"Scales elliptical, thin, 7 to 9 lines in length, nearly half the surface exposed; exposed portion covered with thread-like lines similar to those of the opercula and maxillaries, and which converge towards the posterior angle of the scale.

"C. ORNATUS, Newb. Body fusiform, slender, scarcely wider than the head; size small, not exceeding 4 to 5 inches in length; upper surface of head ornamented with tubercles, which are much larger and more remote than in preceding species; opercula and maxillaries threaded, and like the scales, having stronger markings than in the larger species.

"Radial formula, A.D. 8; P.D.5; C. 24?; A. 6; V.?; P.?.

"C. ELEGANS, Newb. Body fusiform, robust, 6 to 8 inches in length; cranial surface covered with closely-approximated tubercles; surface of opercular and maxillary bones threaded. All the ornamenting of the head relatively stronger than in *C. robustus*, but less so than in *C. ornatus*. Scales similar in form and markings to those of both these species, but more delicate than either. Anterior dorsal fin slightly in advance of ventrals; posterior dorsal as much forward of anal fin.

"Radial formula, A.D. 7?; P.D. 5; C. 22; A. 6; V. 9?."

In the course of the preceding history of the gradual discrimination of the forms which constitute the genera *Cœlacanthus* and *Undina*, the following species have been mentioned:—

Genus.	Species.	Formation.
		CARBONIFEROUS.
Cœlacanthus	1. *lepturus*, Agassiz.	
	2. *Phillipsii*, Agassiz.	
	3. *robustus*, Newberry.	
	4. *ornatus*, Newberry.	
	5. *elegans*, Newberry.	
		PERMIAN.
	6. *granulatus*, Agassiz.	
	7. *Hassiæ*, Münster.	
	8. *caudalis*, Egerton.	
		TRIASSIC.
	9. *minor*, Agassiz.	
		OOLITIC.
Undina	10. *striolaris*, Münster.	
	11. *Kohleri*, Münster.	

Besides these there are *Cœlacanthus gracilis*, Ag. of unknown locality and formation, and the so-called "*Cœlacanthus*" *Münsteri*, which must be excluded from the genus *Cœlacanthus*.

To the important question, how many of these nominal species are truly distinct, and what are their diagnostic characters, I must confess myself unable to give any satisfactory reply.

I have examined the specimens originally named *Cœlacanthus lepturus* by Agassiz, in Lord Enniskillen's collection, and I entertain no doubt that the specimens from the Staffordshire coal-field described in the present decade are specifically identical with these; but I can find no certain diagnosis by which this species is to be distinguished from the *C. elegans* of Newberry (though I by no means affirm the identity of the two), and I have not seen *C. Phillipsii*, *C. robustus*, and *C. ornatus*.

I have examined specimens of *C. Hassiæ* and *C. granulatus* in Lord Enniskillen's collection. They are undoubted Cœlacanths, a specimen of *C. Hassiæ* exhibiting the characteristic anterior dorsal interspinous bone, but no scales were preserved in any of the examples, nor were they in such a state as to allow of any useful comparison of the proportions of the body and fins.

C. caudalis is discussed below. Of *C. minor* I have seen no specimen, and Prof. Agassiz's diagnosis is insufficient to enable me to give any opinion concerning its specific distinctness.

Again, the differences between the genera *Cœlacanthus* and *Undina* appear to me to be anything but clearly made out. The close similarity of the two genera in the broad features of their structure is indubitable; and it is open to doubt whether the differences in the dentition are not more apparent than real.

Under these circumstances I shall adopt the generic and specific names, which have been used by my predecessors, provisionally, and without intending, for the present, to express any opinion as to their real value.

I. Cœlacanthus lepturus, Agassiz.

No. 1. *The specimen represented in Pl. II.* [*Plate* 2], *figs.* 1, 2, 3, 4.

This fossil fish is nearly entire, only a small portion of its caudal extremity being absent. Its total length could not have exceeded five inches.

The length of the head appears to have been about 1·3 in., but the snout is somewhat crushed, and the occipital boundary is but indistinctly indicated.

The depth of the body, at the level of the anterior edge of the anterior dorsal fin (*D*) is 0·95 in. The anterior dorsal fin itself is 0·75 in. distant from the occiput, and 0·2 in. broad at its base. Twelve stout fin rays can be counted in it, the anterior three being shorter than the others, and gradually increasing in length to the fourth, which is about 0·75 in. long. I can discern no ornamentation upon any of these fin rays, which appear to be quite smooth, and become divided into broad quadrate joints in their distal moieties.

The remains of a large interspinous bone are seen at the base of the dorsal fin rays, and supporting them.

The fin rays of the second dorsal have disappeared, but I believe I can perceive indications of its interspinous bone.

The caudal fin (*C*) is very imperfect; the anal and pectoral fins are absent; but the right ventral (*V*) is seen in place, a little behind the level of the anterior dorsal. It is a considerable fin, as large as the anterior dorsal itself.

The scales of this fish are thin, flat, cycloidal, and 0·15 to 0·2 in. in diameter. The middle of the posterior margin of many of the scales (figs. 3 and 4) is produced, so that the exposed portion is nearly triangular. The sculpture consists of raised, continuous, ridges, which converge towards the middle line.

The pectoral arches are strong and broad, and have somewhat spatulate upper ends; they exhibit no sculpture.

Some points in the structure of the skull are so well displayed in this specimen that I have given an enlarged view of it in fig. 2.

The posterior moiety of the roof of the skull (*A*) meets the anterior at an obtuse angle, and exhibits no trace of sutures. The outer surface of this, apparently single, bony shield, is ornamented with minute oval tubercles of enamel, which, posteriorly, run together into short ridges. Very little of the anterior moiety of the roof of the skull is preserved, but so much as remains shows a similar ornamentation.

The right operculum (*Op.*) is broad and triangular; its surface is marked by ridges, which take a radiating course from its anterior superior angle. These ridges are rather more interrupted, and as it were tuberculated, than they are shown to be in the figure.

Between the dislocated operculum and the suspensorial apparatus for the lower jaw, several ossified branchial arches (*Br.*) are visible.

The suspensorium itself consists of a closely united hyomandibular (*H.M.*) and palatoquadrate (*P. Qu.*) portion. The latter is a triangular strong plate of bone, and its downwardly and backwardly directed apex ends in a stout condyle for articulation with the

mandible. Its upper edge is sharp and free, and its anterior thinner angle becomes connected with the skull, but in what manner, the state of the specimen does not enable me to say.

The hyomandibular portion of the suspensorium is, inferiorly, covered by the palatoquadrate, but above, it appears, to be stout and prismatic. External to the anterior two-thirds of the outer edge of the palatoquadrate, what appear to be the remains of a maxilla are visible.

Emerging from beneath the anterior attachment of the palatoquadrate, there is a small process of bone which enlarges at its free end (*d*). A similar process, apparently developed from the prefrontal, is seen in *Macropoma* and *Undina.* In front of this, obscure traces of one or two sharp pointed teeth are visible.

The impressions of the right ramus of the lower jaw, and of one of the displaced jugular plates (*G*) are to be seen below the head.

This instructive specimen (like the others, unless the contrary be stated) was obtained from the Coal measures of Pendleton by Mr. Molyneux, and is now in the Museum of Practical Geology.

No. 2. The specimen represented in Pl. III. [Plate 3], *figs.* 1., 1*a.*, 1*b.*

This is a figure, magnified to twice the natural size, of a small *Cœlacanthus lepturus*, not more than three and a half inches long, and so disposed as to display the unusually perfect caudal extremity very well.

The skull is about 0·7 in. long; and, posteriorly, where it is much crushed, it has about half that width.

It is seen from below, and the interspace between the rami of the mandible (*a, a*) is occupied by the two broad and elongated jugular plates (*G*). The surface of each of these bones exhibits a very peculiar ornamentation, consisting of delicate undulating ridges, which on the whole, run more or less parallel with the outer edges of the jugular plate, but, in front, converge towards its inner edge. The peculiar form and sculpture of the rami of the mandible, are better displayed by other specimens. In front of their symphysis there is a confused mass, doubtless formed chiefly by the premaxillæ, and which exhibits indications of small teeth.

The broad ends of the pectoral arches are displayed at *b*; but the pectoral fins are not visible.

The large, obtusely lobate, ventral is well shown at *V.* It has, at present, fourteen fin rays, which gradually increase in length on either side towards the middle four, which are about equal. These rays

present no sculpture, but the broad jointing of their distal halves is very well displayed.

The remains of the dorsal fin appear at *D*.

The caudal fin has about ten fin rays above and below, which are connected with the neural spines by interspinous bones. The rays are jointed in their distal moieties; and the hindermost ones are shorter than the others, and lie more nearly parallel with the axis of the body. The latter narrows rapidly from the commencement of the caudal fin, and continues scaly to its truncated and evidently broken extremity.

The scales *a*, fig. 1*a*, have the same form and sculpture as in the preceding specimen. Fig. 1*b*. exhibits a magnified view of the ornamentation of part of one of the jugular plates.

No. 3. *The specimen represented in Pl. III.* [Plate 3], *fig.* 2.

The chief interest of this specimen (figured of twice the natural size) arises from its showing at *b* the crushed walls of the ossified air bladder, and, at *a*, what appears to be the interspinous bone of the posterior dorsal fin. Its crura diverge at a somewhat more open angle than that shown in the figure. The anterior dorsal fin (*D*) of this specimen is unusually long.

No. 4. *The specimen represented in Pl. III.* [Plate 3], *figs.* 3, 3*a*, *and Pl. IV.* [Plate 4], *figs.* 1 *and* 2.

Of these figures the first is of the natural size; the two others are magnified, and fig. 2, Plate IV. [Plate 4], has been accidentally inverted. They are taken from the two counterparts of a split specimen, and throw much light upon the structure of the mandible, the jugular plates, and the branchial apparatus.

Each ramus of the mandible (*Mn*), when viewed laterally, as in fig. 2, Plate IV. [Plate 4], (which represents the right ramus) presents a nearly straight lower margin, while the upper edge is sinuous; the upper contour of the ramus attaining its greatest height rather behind its centre, and thence rapidly descending forwards and backwards. In the horizontal plane, the hinder part of each ramus is nearly straight, but its anterior end curves sharply inwards towards that of its fellow (Plate IV. [Plate 4], fig. 1), to the symphysis.

The outer surface has an ornamentation composed of minute ridges of enamel, the ridges having a direction generally parallel with the axis of the ramus.

In the elongated oval jugular plate (*G*) of this specimen (Plate IV.

[Plate 4], fig. 1.), the ridges of the ornamentation are more completely transverse to the axis of the plate than in the specimen No. 3 (Plate III. [Plate 3], fig. 2).

The impressions of five strong bony branchial arches are plainly visible on the left side. Minute horny, or osseous, filaments seem to have been set at right angles to the branchial arches along their edges (Plate IV. [Plate 4], fig. 1).

Connecting the branchial arches is a strong median ossification, consisting of an anterior cruciform part, and a posterior elongated spatulate portion. The two anterior branchial arches are connected the one with the outer end, and the other with the base of a transverse arm of the cross; the three other arches unite with the sides of the posterior division, while the long spatulate end lies free between the hindermost pair of arches (Plate IV. [Plate 4], fig. 1). Fig. 3*r*, represents a scale of this specimen magnified.

No. 5. The specimen represented in Pl. IV. [Plate 4], *figs.* 3.

The under surface of a crushed head of *Cœlacanthus lepturus*, showing the ornamentation of the jugular plates. In the collection of Edw. Binney, Esq., F.R.S.

No. 6. The specimen represented in Pl. IV. [Plate 4], *figs.* 4 *and* 5.

These fragments, figured of the natural size, show, in fig. 4, the elongated pelvic bones still connected with a part of the ventral fins; and, in fig. 5, the anterior (D) and posterior (D^1) dorsal fins, apparently but little displaced from their normal position.

No. 8. The specimen represented in Pl. IV. [Plate 4], *fig.* 6.

A very perfect hinder moiety of a *Cœlacanthus*, somewhat larger than any of the foregoing, drawn 1½ times the size of nature.

The persistent notochordal space, with the superior and inferior bony arches and spines, the interspinous bones, and the fin rays, are very clearly displayed. There seem to be 12, or perhaps 13, fin-rays in each lobe of the caudal fin; and, as in No. 2, the posterior fin-rays lie nearly parallel with the axis of the body. The jointing of the broad distal portion of these rays is every distinct. The scaly central part of the body (C^1) passes backwards into a prolongation about 0·1 in. wide, also covered with small scales, and beset along its upper and lower margins with small fin-rays, which appear to be simple and unjointed.

Cœlacanthus lepturus attained considerable dimensions. A specimen obtained by Mr. Molyneux from the Ladies Well Colliery, Cheadle, North Staffordshire, shows that the parieto-occipital region of the head was at least 1·5 in. long, and that the length of the whole head could not have been less than 3½ inches. The entire fish, therefore, was probably not less than 12 to 14 inches in length.

In this large specimen the surface of the parieto-occipital region, and of so much of the frontal region of the skull as is preserved, as well as that of the opercula, are covered with oval tubercles of enamel set so closely as to leave no interspace. On the parieto-occipital shield these tubercles are about $\frac{1}{60}$ of an inch long, but on the opercula and the fragments of the external facial bones they become both actually and proportionally longer. The left pectoral fin is about an inch and a half long, and has a distinct though small, scaly lobe. The ornamentation of the scales is quite as in the smaller specimens, but the scales are fully 0·3 in. in diameter.

II. Cœlacanthus elegans, Newberry.

I am indebted to Sir Philip Egerton, Bart., for the opportunity of studying several specimens of the *Cœlacanthus elegans* of Dr. Newberry, from Liston, Ohio, and I figure three of them for comparison with *Cœlacanthus lepturus.*

No. 1. *The specimen represented in Pl. V.* [Plate 5], *fig.* 1.

The caudal extremity of this specimen is broken off, but its extreme length, when entire, could hardly have exceeded 5·75 in. The length of the head is 1·3 in., so that the whole body was between four and five times as long as the head.

The fish is crushed in such a manner as to have its depth unnaturally increased, and the right ventral fin is seen to be detached, and lies below the left. From the line of the back at the front boundary of the first dorsal fin, to the opposite point of the belly is 1·4 in.

The scales, in a tolerably good state of preservation, are about 0·15 in. in diameter, thin and flat, and would be circular were not their posterior margins produced into an obtuse point (Plate V. [Plate 5], fig. 3).

Each scale is ornamented with narrow, wavy, nearly parallel ridges, which converge towards and meet along, a line drawn through the centre and the point of the scale. I observe no marked differences among the scales of different parts of the body, nor any trace of a lateral line.

The neural arches have the ordinary form, and are close set. A series of subvertebral arches correspond with them in the caudal region, but there is no more trace of ribs in this species than in *C. lepturus.*

Fourteen or fifteen fin rays, jointed in their distal portions, are discernible in the anterior dorsal fin (*D*), and seven or eight in the posterior (D^1), the anterior edge of which, is opposite the most anterior subvertebral bones. A large single interspinous bone supports the anterior dorsal fin, but the interspinous bone of the second dorsal is concealed.

The anal fin (*A*) is but obscurely indicated, but lies rather in front of the anterior margin of the second dorsal. The left ventral fin is in place, and is situated as in *C. lepturus.* The strong and broad bones of the pectoral arch are devoid of sculpture externally, and in form resemble those of *C. lepturus.*

The upper contours of the anterior and posterior regions of the skull do not pass evenly into one another, but meet at an obtuse angle. The operculum is large, extending from the roof of the skull to near the angle of the jaw, and has the form of a triangle with the base upwards. It is ornamented with fine ridges, which, on the whole, radiate from its anterior superior angle. The structure of the skull in front of the operculum cannot be deciphered.

The mandible is in place, though a good deal broken. So much of its outer surface as is preserved exhibits the characteristic sculpture.

Minute conical teeth are visible at the anterior end of the snout, and there is one in the palatine region, but these teeth are detached, and but obscurely visible.

No. 2. The specimen represented in Pl. V. [Plate 5], *fig.* 2.

In this example the tail, with the anal (*A*) and second dorsal (*D*) fins, are well displayed. Twelve fin rays, having the same arrangement as in *C. lepturus*, can be counted above and below, and there is a medial scaly caudal prolongation, which, however, is not sufficiently preserved to show the small fin rays which it doubtless possessed.

No. 3. The specimen represented in Pl. V. [Plate 5], *fig.* 4.

A much crushed head, showing the jugular plates and scales of *Cœlacanthus elegans*, and exhibiting three, or perhaps four, sharply pointed conical teeth, connected to all appearance with the premaxilla. The largest of these teeth is not more than 0·05 in. long. The ornamentation of the jugular plates is like that in *C. lepturus.*

III. Cœlacanthus caudalis, Egerton (Plate V. [Plate 5], fig. 5).

Sir Philip Egerton's excellent account of this species has already been quoted at length, and I describe and figure the type specimen anew, merely for the purpose of comparing it with the Cœlacanths already described, and of using it to supplement the information derived from them.

In fact, although the head of this specimen is much crushed, the extreme end of the tail is absent, and the scales are wanting, the skeleton of the trunk and fins has left the mark of its parts in almost undisturbed relation to one another.

The animal is a little bent up towards the dorsal side. Its length, measured in a straight line, is 4·7 in, ; the head is 1·1 in. long, or as in *C. elegans*, rather more than one-fifth the whole body. The front edge of the anterior dorsal fin (*D*) is distant 1·85 in. from the end of the snout, and the base of this fin is 0·25 in. long. From the front edge of the first dorsal to that of the second (D^1) is a distance of 0·95 in.; the base of the second is 0·2 in. long. The front edge of the upper lobe of the caudal fin (*C*) is 0·7 in. from the front edge of the second dorsal, and 3·6 in. from the end of the snout. Only the right pectoral fin, detached from the pectoral arch and thrown backward, is visible. The two ventrals (*V*) close together, and opposite the level of the posterior margin of the anterior dorsal, are apparently in, or close to, their natural position; they are distant 2·35 in. from the snout.

The small anal (*A*) is opposite the second dorsal, and 3·15 in. from the snout.

The greatest depth of the fish, 0·95 in., is opposite the first dorsal fin.

The pectoral fin (*P*) is rather more than 0·5 in. long, and 0·2 in. broad at its base; it is obtusely lobate, and contains, at fewest, 18 fin-rays. The foremost of these rays are unjointed through the greater part of their length.

The ventral fin (*V*) is 0·6 in. long and about 0·2 in. broad, or of nearly the same size as the pectoral. It is obtusely lobate, and 17 or 18 fin-rays may be counted in it. As in the pectoral fin, the foremost of these fin-rays are shorter than the others, and remain undivided through a great part of their length.

An impression of one, or both, of the pelvic bones (*Pv*) lies in front of the ventral fins, but apparently out of its normal position, as its base is in advance of these fins.

The anal fin (*A*) is somewhat bent upwards and backwards out of its natural position. What there is of it has a length of 0·4 in., a breadth at the base of 0·15 in. Fifteen or sixteen fin-rays may be

counted, and they appear to be similar in structure to those of the pectoral and ventral fins. There is no evidence that this fin was lobate.

The base of the inferior lobe of the caudal fin (*C*) is 0·75 in. long, and exhibits 14 fin-rays, the hindermost of which are nearly parallel with the axis of the body, and probably indicate the natural termination of the fin. The anterior are shorter than the posterior fin-rays, and, so far as they are preserved, none of the fin-rays exhibits distinct joints.

The upper lobe of the caudal fin resembles the lower, and begins opposite to, or perhaps a little in advance of it.

The interspinous bones appear to correspond in number to the fin-rays, (unless there may be one or two in front which have no fin-rays,) and to be broader at each end than in the middle. Opposite the anterior end of the caudal fin, the whole depth of the body is about 0·65 in., and is divided into five nearly equal areæ by the impression of the notochord in the middle and those of the vertebral arches and interspinous bones, above and below.

The second dorsal fin, (D^1) contains 14 rays ; its basal breadth is 0·2 in., its length not less than 0·5 in. The rays are slender, and only become jointed toward their extremities. The peculiar forked interspinous bone of this fin is not in its place, but I believe I can trace indications of it in the space between the lower edge of the first dorsal and the ends of the neural arches.

The first dorsal (*D*) is fully 0·8 in. long and 0·25 in. broad at the base ; 11 or 12 fin-rays can be counted, which are much stronger than those of the other fins, and, like the others, are only jointed at their tapering distal ends. I observe no spine-like tubercles upon these, any more than upon the other fin-rays. The impression of the broad interspinous bone of this fin is plainly visible *in situ*.

About 23 close-set superior, or neutral, ossified arches, occupying about 0·5 in., may be counted immediately behind the head. The spinal column is there interrupted for nearly the same distance, and a solitary neural arch is seen thrown down out of the series. Behind this point the neural arches are undisturbed, and opposite them, on the ventral side of the body, the series of subvertebral arches commences. That the point at which these commence is, in fact, part of the caudal region is shown by its relation to the position of the ventral fins. More than 40 neural arches can be counted behind the break, and there were therefore probably not fewer than 80 in the whole series. The number of subvertebral arches cannot be satisfactorily ascertained. There are no ribs in the dorsal region.

I am inclined to think that a distorted and V-shaped elevation which occupies the portion of the cavity of the body immediately under the anterior dorsal fin, is the remains of the ossified air bladder.

The head is so crushed that nothing definite can be made of its structure. The strong pectoral arches are discernible immediately behind it, but they also are much crushed.

No sculpture is visible upon what remains of the cranial bones.

IV. Cœlacanthus elongatus, Huxley.

The specimens to which I have applied this name, rather because I cannot identify them with any other species than because they have good positive characters of their own, are all mere impressions in shale from Ballyhedy, near Ballinhassig, county of Cork, Ireland. They were sent to me by my colleague, Professor Jukes, the local director of the Geological Survey of Ireland, and are now in the collection of that Survey.

No. 1. *The specimen represented in Pl. V.* [Plate 5], *fig.* 6.

This fish was probably about 3·5 in. long when entire. The head is somewhat less than one inch long, appears more elongated and tapering in proportion than in the other species.

The anterior edge of the dorsal fin is 0·65 in. from the head, and is thus further back in proportion ; the depth of the body at this point is 0·5 in.

The cranial impression is marked by deep and irregularly disposed lines, the correspondence of which with the probable outline of the cranial and facial bones is not apparent. Besides and between these markings the impression of the skull presents traces of a minutely granular, or lineated, sculpture.

The anterior dorsal fin (*D*) is 0·5 in. long, but only eight or nine of its fin rays are preserved, and there is no trace of the interspinous bone. There is an interval of 0·7 in. between the bases or the anterior and posterior dorsal fins, and the latter (D^1) exhibits 13 or 14 long fin rays, with one or two short ones in front ; the whole fin is 0·4 in. long.

The impressions of both bones of the pectoral arch are discernible, and the confused fin rays of apparently both pectoral fins (*P*). Each fin was about 1·5 in. long. About 37 neural arches may be counted, those nearest the head being smallest. There are no dorso-abdominal ribs, and the subventral bones begin nearly opposite the 25th neural arch. No ventral fins, nor any part of the caudal, are visible, in consequence of the breaking away of the matrix in their region.

No. 2. The specimen represented in Pl. V. [Plate 5], *fig.* 7.

This is very like the preceding, but in some respects it is more complete. The extreme length is 3·6 in. The length of the head is about 0·85 in., unless the anterior end of the snout is absent. The head presents longitudinal and oblique groovings similar in their general character to those of the foregoing example: and, as in the latter, there is a rounded depression, like an orbit, situated at the junction of the posterior and the anterior three-fourths of the length of the head. Here and there, indications of a granular and lineated sculpture are visible. The impressions of the bones of the pectoral arch are well seen; they appear not to have been so rounded and expanded above as in the other Cœlacanths.

Twenty-five dorsal abdominal neural arches, unaccompanied by ribs, can be counted (there were probably several more), before the series of subvertebral bones begin, on the under side of the space occupied by the notochord.

The front edge of the anterior dorsal fin (*D*) is 0·6 in. from the posterior end of the head. At least ten rays can be counted in it, but its distal end being hidden under matrix, its precise length cannot be ascertained. An interval of 0·6 in. separates the bases of the two dorsals, and so much of the second (D^1) as is visible, shows it to have been, as in the preceding specimen, stouter than the first dorsal. Thirty-seven neural arches can be counted in front of the point of commencement of the upper lobe of the caudal fin (*C*), the impression of which shows it to have had the ordinary Cœlacanth structure. The anal and ventral fins are not visible. Both pectorals (*P*) are seen, the right nearly in place. Its rays are very delicate and nearly 0·7 in. long if traced to their extreme ends. No trace of the pelvic bones, or interspinous bones, is visible.

This Cœlacanth appears to have attained much larger dimensions, as a fragmentary specimen from the same locality has neural arches 0·45 in. long, whilst those of the example described nowhere reach 0·2 inches.

A fragment of a caudal extremity of a Cœlacanth, in the same collection, leads me to suspect that a second, deeper and shorter bodied, species may have coexisted with this.

Numerous specimens sent to me by Prof. Jukes demonstrate the existence of a true *Cœlacanthus* in the Coal measures of Ballybunnion, Kerry. The largest impressions belong to fish about 12 inches long, and the fossils vary from this size to less than six inches. In none are the scales or the form of the head preserved, and hence I can give

no strong opinion as to the specific distinctness of this Cœlacanth, or its identity with other species. I am inclined to think, however, that it is rather more slender than *C. lepturus*.

The Genus *HOLOPHAGUS*, Egerton.

The unique specimen upon which this genus is based is thus described by Sir Philip Egerton in a note at page 19 of the "Preliminary Essay" of the tenth Decade :—

Holophagus Gulo.

"Mr. Harrison's specimen wants the anterior portion from the dorsal and pectoral fins forwards. From the insertion of the dorsal fin to the extremity of the tail it measures 11½ inches, and 4½ inches in depth. The stomach is distended with a recently swallowed Dapedius, and a large coprolite occupies the rectum. The first dorsal fin springs (as in *Macropoma*) from a single disc, resulting from the coalescence of the interneural spines. It contains eight long, thick, undivided, and multi-articulate rays. They are beset with numerous short spines or tubercles. The second dorsal is situated 4 inches behind the first. Between the two is seen a strong bifurcate interneural ossicle, which has been displaced forwards from its proper position at the base of the fin. The second dorsal fin contains sixteen rays. The anterior ones are short and slender. The succeeding ones are long, broad, and multiarticulate, but not tuberculate. The base of the fin is obtusely lobate, with a scaly investment. The pectoral fins are much mutilated. Judging from what remains of them, and from some indistinct impressions, they seem to have been of great size. The anal fin occurs immediately below the second dorsal fin, with which it corresponds in form and structure, but contains many more rays. The ventral fins are mutilated, but their position below the first dorsal fin is indicated by the preservation of a pair of strong T-shaped pelvic bones, having their longer limbs directed forwards, and nearly reaching the base of the pectoral fins. The caudal fin is of great size and presents in an eminent degree the most special and characteristic feature of the Cœlacanthus family, namely, the interposition, in the caudal region, of an interneural between the neural and demoneural spines. The base of this spine abuts upon the extremity of the neural spine, and unites with the true fin ray by an overlap or splice. This structure coincides with that observed in *Undina*. In *Macropoma* the bone of the interneural spine is bifurcate for the reception of the distal extremity of the neurapophysis. A small supplemental fin extends an inch beyond the larger caudal fin, as in *Undina* and *Cœlacanthus*.

The notochord is unossified. The apophyses, both above and below, have very wide bases. The scales are curvilinear, and covered with a vermiculate pattern on the upper surface, occasionally broken up into small tubercles."

The specimen referred to in the foregoing description is in the Museum of Practical Geology, and is figured, one-half the size of nature, in Plate VI. [Plate 6]; with enlarged views of a scale, of anal and of caudal fin-rays. *D* is the first dorsal fin; D^1, the second dorsal fin; $D^1$1, its interspinous bone; *A*, the anal fin; *C*, the caudal fin; C^1, the supplemental caudal fin-rays; *Pv*, the pelvic bones.

The Genus *MACROPOMA*, Agassiz.

I. Macropoma Mantellii, Agassiz (Plates VII. and VIII.) [Plates 7 and 8].

Attention was first directed to this remarkable genus of Cœlacanth fishes, in 1822, by the late Dr. Mantell, who, at page 239 of his work "The Fossils of the South Downs," gives the following account of the specimens which had fallen under his observation:—

Amia? Lewesiensis. Tab. xxxvii., xxxviii.

"The length of this ichthyolite generally exceeds 18 inches, the head being equal to one-third of the whole; the width is about 4·5 inches. The body is of an elongated form, slightly compressed, scaly and reticulated.

"The scales are of a rhomboidal shape, and beset with numerous small adpressed spines, producing a scabrous reticulated appearance, not unlike the surface of some kinds of *Balistes*. The head is angulated; the orbit large; the opercula smooth and rounded; the jaw dentated and nearly straight. The teeth in the upper maxilla are conical, pointed, and rather flat; there are about 40 on each side, of which the eight or nine anterior ones are the largest. Those of the lower jaw are exceedingly small and very numerous. The dorsal fins are two in number; the anterior one (*a* Tab. xxxvii.) is placed in a sulcus or groove in the back, and appears to have been capable of erection or depression; it consists of eight strong rays, the two first being garnished with spines. The posterior dorsal fin (*b*, Tab. xxxvii.) is remote from the other, and composed of numerous delicate rays. The pectoral fins are placed on the thorax, near the lower margin of the opercula. The ventral fins (*c*, Tab. xxxvii.) are attached to the abdomen opposite to the anterior dorsal fin. The anal fin is unknown. The tail appears to have been rounded, but no perfect specimen of

this part has been obtained. The tongue is occasionally preserved (*vide* Tab. xxix., fig. 6; Tab. xxxiv., fig, 7.) It is of a triangular form, and its surface is covered with numerous papillæ. The air bladder is of an elongated oval shape, and lies in the abdomen immediately beneath the spine."[1]

Dr. Mantell compares the fish with *Mugil, Balistes* and the *Amia ignota* of De Blainville.

In the third chapter of the second part of the second volume of the "Recherches," Agassiz established the genus *Macropoma* for the fishes discovered by Mantell: and he describes the characters of the new genus and discusses its relations in the following terms:—

"It is incontestable that this genus has striking affinities with the genus *Cœlacanthus*. The body is similarly thick, and the fins have a like arrangement. There are, as in *Cœlacanthus*, two dorsal fins, one of which lies opposite the interval between the pectorals and the ventrals and the other opposite the space between the ventrals and the anal. The second dorsal is supported by a very strong bone, which is also found in many other genera of the family. The caudal is largely developed, and greatly surpasses all the other fins. The scales also present a certain resemblance to those of *Cœlacanthus*, in size as well as in form. But, on the other hand, the structure of the rays is very different; their cutting edges are beset with spines, and they doubtless served as protective weapons to the animal, while those of the *Cœlacanthus* are smooth. The skeleton is strong, but I have not been able to satisfy myself whether the bones are hollow or not."

MACROPOMA MANTELLII, Agass.

" . . . . . . The head is very large; it equals more than one-fourth of the length of the body; its bones are strong, and their surface is finely dotted. In the specimen figured in Plate 65 a the roof of the cranium, the bones which surround the orbit, the jaws, a part of the opercular apparatus, the branchial arches, and a part of the thoracic girdle are readily distinguishable in their natural relations.

"The lower jaw has a very irregular outline; its dentary edge is grooved in front, and descends towards its articulation with the os quadratum. The pterygopalatine arch is very wide, especially behind. It is the palatines and the vomer which carry the largest teeth. On the other hand, the superior maxillary, which forms the edge of the upper jaw, has none.

[1] "It may seem scarcely credible that a part of such delicate structure should be preserved in a mineralized state, yet the fact is unquestionable. I have three specimens in my collection in which it is clearly shown."

"The fore part of the head [*front*] is concave, and rises as a rounded projection above the orbit. The posterior suborbitar is a large osseous plate, granular on its surface like the cranium; the anterior suborbitars are elongated. The operculum has its posterior edge rounded. The branchial arches are very large and strong, whilst the thoracic girdle is proportionably weak. As in the pike, this arrangement is doubtless calculated to facilitate the deglutition of a large prey.

"The scales are large, and envelope the whole body in a thick cuirass, which appears to extend very far on to the caudal, judging by the impressions observable upon the lower lobe of the tail. The surface of all the scales is granulated, and this granulation is so persistent as to be recognizable when the scale is much worn. I have represented in Plate 65 b, fig. 1, a portion of the body of a fish which I believe to be the young of the same species, and whose scales are in so perfect a state of preservation that their minute structure may be studied in detail. They have for the most part a rhomboidal form, at least they appear thus when superposed (as in nature). Isolated they present a very different form, when the root of the scale is preserved, as in fig. 3. Plate 65b. Examined with a lens it is seen that the superficial rugosities are produced by a quantity of little elongated tubercles, or rather of small pointed cylinders, which cover all the visible part of the scales. The largest and longest are in the middle of the scales; those at the sides are shorter and more slender: the covered part of the scale is completely deprived of them; it is smooth, and exhibits only the lines of growth (Plate 65 b, fig. 3). For the rest there is no very marked difference among the scales of different parts of the body. . . . . . . I have not succeeded in discovering any trace of the lateral line; doubtless the superficial tubercles prevent the mucous canals from being recognized.

"The fins present peculiarities no less singular than those of the scales. All the rays are stiff and very stout; they do not dichotomize, and are not jointed; but on each side they are beset with a series of strong spines, turned towards the extremity of the ray. Their bases are divided into two branches, so as to form a cleft which embraces the apex of the interspinous bone. At least, the dorsal fin rays are constructed in this manner . . . . There are two dorsal fins; the first is situated immediately behind the pectoral girdle; its rays are long and very strong. The second, situated opposite [*en face*] the anal (Pl. 65 a), has rays which are less robust, shorter, and more numerous, borne by a great bifurcated interspinous bone. In this specimen the fin has not fewer than 13 rays. The ventrals and the

anal are nearly of equal size; the ventrals are opposite the middle of the space comprised between the two dorsals; the anal is rather further back than the second dorsal. Both are composed of very short, but strong rays.

"The caudal is extremely broad, and if, as everything seems to show, it is entire in the specimen (Pl. 65a), it offers a most curious type of structure, a kind of great fan, all of whose rays appear to be equal. It is probable that it was rounded, as in certain Sauroids, at least no difference is observable between the upper and the lower rays. This fin is, in addition, supported in equal proportions by the superior and inferior caudal spinous processes, and the vertebral column is nowise bent upwards, as is the case in all the inæquilobed Ganoids. Its rays are very strong. I have counted some twenty in the lower, and a few more in the upper lobe. All are nearly equal, and only the anterior ones, situated at the base of the fin, are a little shorter. Their structure is the same as in the other fins, that is to say, the visible part of the ray is supported by a shorter ray, which is itself supported by the spinous processes of the vertebræ. The greater part of the caudal vertebræ thus afford support to the caudal fin, and it is this which gives the fin its great width.

"The internal skeleton of our *M. Mantellii* is in general robust. The apophyses are short but large, at least in the neighbourhood of the tail; those of the abdominal vertebræ are longer, and bent more backward. The vertebræ, on the other hand, are small and delicate relatively to the size of the fish.

"But our knowledge of this remarkable fish is not limited to the skeleton; many of the soft parts are also preserved. Among others, there are, in Mr. Mantell's collection, many specimens of the trunk in which the stomach is distinctly recognizable. (Pl. 65c, fig. 1, and Pl. 65d, fig. 1.) It resembles a squamose cylinder, an appearance which is evidently the result of the changes which have taken place in the different membranes which compose its walls; vascular trunks can even be perceived. These remains are commonly accompanied by coprolites, which have evidently been formed in the intestine. They have a general resemblance to those of Sauria, and are sometimes grooved in the same way. I have represented a series of them in Plate 65a, to show the variety of forms which they affect. It is these coprolites which have been described by many authors as petrified fir-cones." (P. 177.)

In the explanatory notes which follow Prof. Agassiz speaks of the "bassin," without describing it, and of the "plaque qui tient lieu de rayons branchiostègues."

When Professor Agassiz published his "Monographie des Poissons Fossiles du Vieux Grès Rouge," his views respecting the systematic position of *Macropoma* appear to have undergone considerable change. Thus he observes, at p. 61 :—

"J'ai déjà fait remarquer que le genre *Macropoma* de la craie, ainsi que le genre *Undina* de M. le Comte de Münster, cadrent mal avec les autres Célacanthes . . . . C'est dans l'Old Red et dans l'houille que la famille des Célacanthes acquiert son plus haut degré de développement ; passé cette époque elle décline rapidement, et son dernier représentant, qui d'ailleurs est fort douteux, appartient à la craie."

In 1849 Professor W. C. Williamson gave an account of the structure of the scales and the walls of the ossified air bladder of *Macropoma* in his valuable memoir "On the Microscopic Structure of the Scales and Dermal Teeth of some Ganoid and Placoid Fishes," published in the Philosophical Transactions for that year.

Professor Williamson shows that the tubercles which ornament the scales and opercular plates of *Micropoma* are composed of layers of kosmine coated with ganoin, and resting, in the case of the operculum, upon lamellæ of bone, in that of the scales, upon a lamellar substance which contains no lacunæ, but presents layers of irregular tubes interposed between the lamellæ. Successive layers of the tubes cross one another in direction.

At the base of each tubercle, whether on the operculum, or on the scale, there is a cavity, which communicates by one or more canals with the exterior.

The walls of the structure called "air bladder" by Mantell[1] (who seems to have considered the solidity of the parietes of this organ to result from mineralization) and "stomach" by Agassiz, are proved by Professor Williamson to be composed of lamellæ between which are

[1] In the Medals of Creation, 1844, Mantell gives up his first interpretation, and adopts that of Agassiz, but in "The Petrefactions and their Teachings," 1851, p. 437 he writes :—"*Air Bladder (or Stomach ?) of the Macropoma.*—In every example of this fossil fish that I have dissected, there lies within the body, generally nearest the upper or dorsal part of the cavity, a long hollow cylindrical substance, often 7 inches in length, and 1½ inches in diameter, covered with a thin, brittle, scaly integument, which readily separates into two or three laminæ. The anterior part of this organ, which lies close to the posterior margin of the opercular bone, is always imperfect, appearing as if torn or ruptured ; the caudal extremity terminates in a *cul-de-sac*. From the situation and structure of this viscus I supposed it to be an air bladder, and described it as such in the "Fossils of the South Downs," in 1822, but on Professor Agassiz's visit to my museum at Brighton, that eminent naturalist pronounced it to be the stomach. Recent microscopic investigations of the investing integument have however, tended to establish the correctness of my original interpretation of the nature of this remarkable body."

developed large lacunæ, identical with those found in the endoskeleton of the fish. Some of the external lamellæ lose their exact parallelism with those below, and one in particular assumes an undulating arrangement. On both sides of the folds of its undulations large irregular lacunæ are placed. This again is invested by other dense and apparently structureless lamellæ, which fill up the inequalities of the undulating layer, and form the external smooth surface of the organ.

With respect to the functions of this apparatus, Professor Williamson remarks:—

"I am disposed to believe that it has been an organ fulfilling the functions of an air bladder. Its osseous structure would render it capable of resisting a considerable amount of pressure; and if its patulous extremity has been closed up by an elastic membranous appendage capable of acting as a valve, this would enable the creature to regulate its buoyancy, by increasing or diminishing the compression of the contained air, and thus facilitate its movements in either shallow water or at great depths. Except in cases of diseased ossification, the existence of an internal thoracic or abdominal viscus having hard parietes of true bone, is an anomaly which, as far as I am aware, has hitherto presented no parallel in nature."

Professor Williamson finally remarks that the structure of—

"The scale of *Macropoma*, as now described, is wholly different from that presented by any of the ganoid fish noticed in the preceding pages [*Lepidosteus*, *Lepidotus*, *Semionotus*, *Pholidotus*, *Ptycholepius*, *Dapedius*, *Palæoniscus*, *Gyrodus*, *Aspidorhynchus*, *Accipenser*, *Platysomus*, *Megalichthys*, *Diplopterus*, *Holoptychius* [1]]. It bears a much closer resemblance in its leading points to the dermal appendages found amongst the group of true Placoids, between which and the Ganoids *Macropoma* appears to form an inosculating link." (L.c. p. 464.)

In 1857, Sir Philip Egerton described and figured the specimen named *Macropoma Egertoni* by Agassiz, in the ninth of our "Decades," Pl. 10. This fossil, which was obtained from the Gault of Speeton, Yorkshire, exhibits only the anterior half of the fish, comprising the head, the pectoral fin, and the first few rays of the dorsal fin.

"The inclination of the profile line of the head is very steep from the occiput to the orbit, far more so than in the allied species; the orbit is situated in a more advanced position, and the facial line thence to the snout falls much more rapidly. The orbit in this species is large, and a portion of the capsule of the eye is preserved. The

[1] This is not the true *Holoptychius* of the Old Red, but a distinct genus, *Rhizodopsis*.

frontal bones are wide, coarse in texture, and bear a few scattered granules on their exterior surface. The borders of the upper jaw are formed of the superior maxillary bones, which are very broad; they are beset with very numerous sharp-pointed teeth, closely arranged, and of uniform size. The lower jaws are also very broad, and the space between the rami is closed by a single glossohyal plate, as in *Lophiostomus*, *Arapaima*, and *Amia*."

As regards the scales, Sir Philip Egerton remarks that—

"The surface ornament is very different; instead of the distinct tubercules so characteristic of that species (*M. Mantellii*); it is composed of minute granules united into longitudinal rows, with only a few small tubercles interspersed occasionally on some of the larger scales."

I venture to doubt that this fish belongs to the genus *Macropoma*, for the following reasons:

1° The upper contour of the skull is quite unlike that which is seen in *Macropoma* and appears to be characteristic of the Cœlacanths in general.

2° In no *Macropoma*, and in no Cœlacanth, however well preserved, have I seen any trace of an ossified capsule of the eyeball.

3° The jugular [glossohyal] plates of *Macropoma*, as of all Cœlacanths, are double and not single.

4° The shape of the lower jaw is quite different from that which is so characteristic of the same part in *Macropoma*, and the maxilla and other bones of the face are very different.

5° The figure clearly displays several strong osseous ribs, while neither in *Macropoma*, nor in any other Cœlacanth, have such ribs been observed.

6° The pectoral fin, judging by the disposition of its fin rays, does not seem to have been lobate, and the fin rays themselves appear to be articulated throughout, and not entire at their proximal ends, as in *Macropoma*.

I conceive the evidence adduced to be sufficient to prove that "*Macropoma*" *Egertoni* is not a "*Macropoma*," and indeed not a Cœlacanth at all. I therefore propose the generic name of ***Eurypoma*** (suggested to me by Sir Philip Egerton) for the fish, retaining the specific title of *Egertoni*.

In a note appended to the description of this fish, Sir Philip Egerton states that he has received from Mr. Beckles "a specimen of a *Macropoma* found in the quarries of Purbeck stone near Swanage. The specimen is not sufficiently perfect to determine the species; it seems to be a shorter and deeper fish than *Macropoma Mantellii*." I.

presume that this is the specimen to which Dr. Mantell refers ("Wonders of Geology," p. 359).

The passages which I have quoted include, I believe, all the statements of any importance which have been published respecting the organization of *Macropoma Mantellii*. I propose to supplement the information which they contain by the following remarks upon the structure of the skeleton of this fish.

The Spinal Column.—This is as completely devoid of ossified vertebral centra as in other Cœlacanths, and its structure exactly corresponds with that of the corresponding region in them (Plate VII. [Pl. 7], fig. 1).

The neural arches and spines are continuously ossified, and the former embraced the persistent notochord as in a fork. There are no bony ribs,[1] but the tail is provided with subvertebral bones, which closely resemble the neural arches and spines.

The Median Fins.—No specimen which I have met with shows a terminal prolongation with small fin-rays, but in other respects the caudal fin is similar to that of *Cœlacanthus* and *Undina*.

The anterior margins of the fin-rays of the median fins present near their bases a shallow groove, in which series, at first single, of rounded pits appear. In each of these pits a short pointed spine is fixed.

More towards the distal end of the fin-ray the rows of pits and spines become double, those of the two sides usually alternating. In no specimen I have met with does a fin-ray present any indubitable articulation. It is probable that the extreme ends were articulated, but the length of unjointed fin-ray is remarkable in *Macropoma*, as compared with *Holophagus* and *Cœlaecanthus*.

The first dorsal fin is supported by the singular lamellar interspinous bone (Plate VII. [Plate 7], fig. 1), which is as characteristic of the Cœlacanths, as the forked interspinous bone of the second dorsal (Plate VII. [Plate 7], fig. 1), indicated by Agassiz. The true form of the first dorsal bone is best exhibited in No. 4,260 of the British Museum, which shows it to be ploughshare shaped, the anterior margin being oblique, and much longer than the posterior. Several ridges radiate

[1] The only specimen of *Macropoma* in which I have observed the slightest indication of ribs, is No. 25,782 in the British Museum. In this example four or five elongated bones lie on the left side and partly covered by the walls of the air bladder; but it is impossible to be certain that they may not be displaced neural spines. In *Holophagus* there are impressions of a few short rib-like bones below the posterior part of the dorsal region of the vertebral column.

from its upper edge downwards and forwards to its anterior inferior angle and inferior edge.

The Pectoral and Ventral Fins.—The pectoral fins are supported by a very strong bone, curved so as to be concave forwards, flattened from side to side, and giving off a process upwards and backwards, so as to appear bifurcated above. (Pl. VII. [Plate 7], fig. 4 *b.*)

The ventral end of each pectoral arch widens out in a direction transverse to the axis of the body, and becomes concave from side to side behind, so that this part of the bone takes on much the appearance of a marrow spoon. This is particularly well seen in No 4,251 of the British Museum Collection.

I have met with only one specimen of the chalk *Macropoma* which shows the structure of the pectoral fin distinctly. In this (Coll. British Museum, 4,258) the right pectoral is thrown forward, and seen from the inner side (Plate VII. [Plate 7], fig. 5). The rays, about 20 in number, decrease in strength from before backwards, and their inner ends are so arranged as to show that they fringed an obtuse lobe. On this no trace of scales was discernible, but the left pectoral, which is imperfectly preserved, shows the remains of a covering of small scales with a tuberculated ornamentation.

The pelvic bones are very long, and each has, at its base, a strong process directed at right angles to the axis of the bone, and meeting its fellow of the opposite side (Plate VII. [Plate 7], fig. 1).

There is a specimen showing a ventral fin in the British Museum (No. 25,944), in which the fin-rays are so disposed as to lead me to believe that it was lobate.

The fin-rays of the paired fins do not seem to have possessed the spinous ornamentation along their anterior edges, which is seen in the median fins..

The Skull.—The roof of the skull (Plates VII. [Plate 7], fig. 1, VIII. [Plate 8], fig. 2) is divisible in *Macropoma*, as in *Cœlacanthus*, into two moieties, an anterior or frontal (B), and a posterior or occipito-parietal (A), which meet at an obtuse angle, the occipito-parietal moiety being nearly parallel with the base of the skull, while the frontal slopes obliquely forwards and downwards to the snout; the occipito-parietal portion is slightly convex from before backwards, and more so from side to side; while the frontal portion, though convex from side to side, is slightly concave from before backwards.

Viewed from above, the occipito-parietal shield (A. fig. 2, Pl. VIII.) [Plate 8], has a trapezoidal form, being more than twice as wide behind as in front, in consequence of the production of its

postero-lateral angles. A median sutural line distinguishes it into two halves; and, in the specimen represented in fig. 1., Pl. VIII [Plate 8], what appears to be a true suture runs obliquely from the median suture outwards and forwards to the outer margin of the parieto-occipital shield, cutting off a large triangular plate of bone, which appears to represent the so-called "*squamosal*" and the *suprascapular* (*S. Sc.*) of ordinary fishes from the proper parietals (*Pa*).

The sculpture of this part of the roof of the skull presents the form of reticulated ridges and grooves, directed more or less transversely, with interspersed dots and splashes of enamel.

The frontal shield (B, fig. 2, Pl. VIII.) [Plate 8], similarly viewed from above, is rounded in front, somewhat constricted in the interorbital region, and truncated behind, where it joins the parietals.

Like the posterior shield, it is divided by a median longitudinal suture, and in the specimen figured in Pl. VIII. [Plate 8], it presents indications of the existence of a transverse dentated suture at its most constricted part.

In the same specimen, which is perhaps young, the proper frontal bones appear to be very narrow, the outer third of each being formed by a fringe of apparently distinct marginal ossicles (*x*); but these seem, eventually, to become completely united with one another, and with the frontals. The surface of the frontal shield exhibits a pitted and reticulated sculpture, like that of the occipito-parietal, which is most distinct on the marginal ossicles. The dots of enamel are scanty, and scattered at wide intervals.

The *basis cranii* (*a*, *b*, *c*) is formed by a layer of bone, which is continuous, and presents no traces of sutures, between *a* and *b*. Behind *b* it is defective for some distance, but reappears in front of *c*. It doubtless represents, in the greater part if not the whole of its extent, the *parasphenoid* of ordinary fishes.

Between the orbits this *parasphenoid* has the form of a stout bar of bone, grooved above, convex and smooth below; but it becomes flattened out from above downwards, both anteriorly and posteriorly. Anteriorly, it ends as a spatulate plate (Plate VIII. [Plate 8], fig. 3*a*), which has prominent lateral margins, bounding a tranversely concave under surface, over which are scattered multitudes of minute granular teeth, those on the margins of the plate being somewhat larger than the rest. The dentigerous plate may represent a vomer, but in no specimen that I have seen can it be distinguished from the parasphenoid.

Posteriorly, the parasphenoid is broken, but probably passed into the flat bony floor of the parieto-occipital division of the skull, which may either be an extension backward of the parasphenoid, such as exists in the sturgeon, or may be formed by coalescence of the latter with a true basi-occipital.

Above its spatulate dentigerous part, the basal bone passes upwards and outwards into strong lateral plates (Plate VIII. [Plate 8], fig. 1, *Pr. f.*), which are concave outwards, and unite with the frontal shield. They represent the *prefrontals.*

Each prefrontal gives off from its anterior end, just above the rounded extremity of the dentigerous plate, a stout process (Plates VII. [Plate 7], fig. 6, VII. [Plate 7], figs. 1 and 3, *d*), which passes downwards and outwards, and ends by a free rounded extremity at the margin of the gape, close to the anterior end of the maxilla. This appears to represent the process of the prefrontal bone with which the palatine articulates in ordinary fishes.

The interorbital space above the parasphenoid, from the posterior margins of the prefrontals as far as a point a little in advance of the junction of the fronto-nasal and parieto-occipital shields, seems to have been devoid of ossifications answering to the orbito-sphenoids and alisphenoids; but further back the sides of the para-sphenoid pass indistinguishably into the *pro-otic* bones. Each of these is a large plate of bone, rising perpendicularly towards the roof of the skull, which it nearly reaches in front. Further back it sends out two great processes, one superior and the other inferior, at right angles to its own plane.

The superior process (Plate VIII. [Plate 8], fig. 1, *e*), curving outwards abuts against the under surface of the occipito-parietal shield, close to the middle of its outer margin, and furnishes an articular facet for the proximal end of the hyomandibular bone (Plate VIII. [Plate 8], fig. 2, *H.M.*).

The superior process of the pro-otic is separated by a deep oval fossa from the inferior process (Plate VIII. [Plate 8], figs. 1 and 2, *f*). which is a stout plate of bone, convex from above downwards on its outer surface, and ending in front by a free thick edge, represented somewhat too round in Pl. VIII. [Plate 8], fig. 2. The lower incurved edge of this scroll-like plate does not come into contact with the osseous basis cranii, which hereabouts begins to be defective.

The root of the superior process (Pl. VIII. [Plate 8], fig. 1 *e*) separates two slit-like foramina which lead into the anterior of the skull, and probably gave exit to divisions of the fifth nerve. From the upper and external edge of the inferior process a vertical bar of bone

is sent off and, abutting against the superior process, bounds an oval fossa behind.

Externally and posteriorly, the pro-otic abuts, by an abruptly truncated and perpendicular face, against another stout lateral osseous mass (*g*), which appears to represent the *opisthotic* and *exoccipital*. From this three processes pass, one ascending, which lies against the vertical bar (f^1) of the pro-otic; a second external and ascending process (Pl. VIII. [Plate 8], figs. 1 and 4, *h*) passes upwards and backwards to unite with and support the supra-scapular part (*S. Sc.*) of the parieto-occipital shield. The third process (Pl. VIII. [Plate 8], figs. 1 and 4, *i*) is directed outwards from near the base of the skull (perhaps arising chiefly from the parasphenoid), and ends in a free obtuse surface, against which the middle of the hyomandibular suspensorium abuts (Pl. VIII. [Plate 8], fig. 2). Behind the part from which these processes are given off, the opisthotic and ex-occipital ossification is continued backwards as a vertical plate, which forms a large part of the postero-lateral walls of the cranial cavity. Between this plate and the processes of the opisthotic there is a deep fossa, floored below by a thin plate of bone (Pl. VIII [Plate 8], fig. 4, *k*) which forms a sort of continuation of the lower edge of the third process of the opisthotic (*i*) into the base of the skull.

The lateral "exoccipital and opisthotic" plates do not reach the roof of the skull superiorly, but end in a free edge, posteriorly; they diminish to a height of not more than one-eighth of an inch above the base of the skull. From the point where it is lowest (Pl. VIII. [Plate 8], fig. 4, *l*) the base of the skull rapidly diminishes in breadth, and ends at *c*, by a free rounded extremity, which is so fractured that its precise shape is not determinable.

A thin plate of bone (Pl. VIII. [Plate 8], fig. 4, *m*) forms a low arch over this part of the skull, and is continuous with the basal plate below.

It is not improbable that this arch may represent an anterior vertebra corresponding with one of those which, in the *Ganoidei*, commonly coalesce with the occipital region of the skull.

The pro-otic bones of opposite sides are not separated by a greater distance than the width of the presphenoidal bone in front and below, but, above, they are somewhat more distant.

The anterior end of the snout of *Macropoma* is constituted by a single bone having the form of a triangle with its base downwards, with a convex anterior and concave posterior surface (Plate VII. [Plate 7], figs. 3, 4, and 6). The convex face is beset with small

cylindroidal teeth, but at the postero-lateral angles of the oral, or lower, margin of the plate, several larger curved and pointed teeth are attached.

The posterior concave face is smooth, and seems to have played over the ethmoidal cartilage.

This bone may either represent the *premaxillæ* coalesced, which is the interpretation that first suggests itself; or, on the other hand, it may be a *vomer*, such as would be formed if the vomerine teeth of *Lepidosiren* were supported upon a common bony base. In the latter case the premaxillæ remain to be discovered.

The hyomandibular, quadrate and pterygoid elements of the face are represented in *Macropoma* by a great triangular plate of bone, in which I have not been able to discover any distinct sutures. The outer and upper surface of this "pterygo-suspensorial" bone, and its general form, are well shown in fig. 3, Pl. VII. [Plate 7], while the proper contour of the hinder half of its lower edge is seen in fig. 6 of the same plate. The inner surface of an entire pterygo-suspensorial bone is beautifully displayed in No. 4,246 of the British Museum collection.

The whole plate is so twisted upon itself that, anteriorly, its surfaces look almost downwards and upwards, while posteriorly, they look inwards and outwards. The anterior angle is comparatively thin and rounded off, and extends forwards to the level of the prefrontals (Pl. VII. [Plate 7], fig. 3; Pl. VIII. [Plate 8], fig. 3), where it articulates with the bone *Pl.*, which it underlies.

The posterior inferior angle is formed by a very stout neck which bears the transversely elongated condyle for articulation with the mandible. This condyle has a subcylindrical pulley-shaped articular surface, somewhat excavated in the middle, like the distal end of a humerus.

The upper and posterior angle of the bone, *H.M.*, is likewise formed by a strong neck, which expands above into a broad head, and articulates thereby with the side walls and roof of the skull (Pl. VIII. [Plate 8], fig. 2).

The outer and upper surface of this bone is remarkably smooth and polished. The inner surface, on the contrary, with the exception of a small strip belonging to the posterior part of the quadrate, is evenly covered with minute asperities, which have for the most part, more the aspect of tubercles of enamel than of teeth. Along the outer edge, however, they become longer, sharper, and more tooth-like.

In Pl. VIII. [Plate 8], fig. 3, the anterior end of the left pterygo-

suspensorial bone is seen to pass to the ventral side of, and become connected with, the bone *Pl.*, which is convex from side to side below and correspondingly concave above. The inner edge of this bone articulates with the prefrontal, and I conceive that it represents the *palatine*.

The concave upper surface of the right palatine is well seen in No. 4,241 in the British Museum ; and here again the bone is connected on the inner side with the prefrontal, and on the outer, with the anterior end of the pterygo-suspensorial. In the specimen represented in Pl. VIII. [Plate 8], fig. 3, there are no teeth upon the oral surface of either of these bones ; but I believe that such teeth existed, inasmuch as No. 4,237 B.M., the head of which is represented in fig. 3 Pl. VII. [Plate 8] shows, in the anterior of the mouth, a convex plate *Pl.*, covered with small teeth. In this specimen and in No. 4,252 B.M. (Pl. VII. [Plate 7] fig. 6), certain sharp, curved, conical teeth, *bb*, are visible, which certainly belong neither to the maxilla nor to the bone *x*, and may have been attached to the palatines.

The *Maxillæ* (Pl. VII. [Plate 7], fig. 6; Pl. VIII. [Plate 8], figs. 2 and 3) are slender bones which lie alongside the outer margin of the pterygo-suspensorial bone, and form the edge of the gape. Their lower edges are beset with small curved teeth. Their anterior connexions are not displayed in any specimen I have seen. Posteriorly, each abuts upon the apex of an elongated triangular "postmaxillary" bone which fills up the interval between the suborbitals, opercula, and mandible, and covers the quadrate articulation.

Each ramus of the mandible is very stout, and is deepest in the middle third of its length (Pl. VII. [Plate 7], fig. 6), where its upper margin is nearly straight. Posteriorly, the upper margin diminishes in height rather gradually ; but, anteriorly, it falls rapidly, being as it were excavated towards the symphysis.

In the mandibles, which are represented in Pl. VII. [Plate 7], the greater part of the angular-articular and dentary elements have been broken away leaving only the plate which answers to the splenial of reptiles (fig. 3., *Spl.*). And it is this plate which gives rise to the height and straightness of the upper edge of the middle third of the ramus.

The angulo-articular element of the mandible, which forms the outer part, if not the whole, of the ramus at the articulation, rapidly diminishes in height, and leaves the outer surface of the splenial bare as it passes forwards. It then meets the dentary, fitting into a V-shaped space afforded by the latter.

The dentary, passing forwards, suddenly rises into a kind of

shoulder, *y* (fig. 4, Pl. VII. [Plate 7]), which applies itself to the anterior part of the outer surface of the splenial.

In uninjured specimens the whole outer surface of the angulo-articular is covered with tubercles of enamel. Similar, but more scattered, tubercles ornament the dentary; but the outer surface of the splenial, exposed between the process *y* and the front and upper margin of the angular-articular, is perfectly smooth.

There is a distinct suborbital half ring (Pl. VII. [Plate 7], fig. 1), formed to all appearance of a single bone, or of several bones which have coalesced, and presenting a granular external sculpture. The posterior part of the suborbital ring is much broader than the anterior, and abuts upon the operculum, behind and below which it comes into contact with the triangular postmaxillary bone; in front and above it, exhibits a deep notch.

The ornamentation of the suborbital bones consists of pits and reticulated ridges, with scattered tubercles of enamel.

The *operculum* (Pl. VIII. [Plate 8], fig. 1, *op.*), is a large four-sided bone. Its upper margin is shortest; its front margin, which is as long as the distance from the roof of the skull to the lower edge of the triangular "post-maxillary" bone, longest. The posterior margin is much shorter, so that the lower edge of the operculum runs very obliquely, from above and behind downwards and forwards.

Traces of a *suboperculum*, much smaller than the operculum, are discoverable in some specimens.

When the outer surface of the operculum is complete, it is covered with close-set conical enamel tubercules, like those of the roof bones of the cranium.

Two large *jugular plates* occupy the whole interval[1] between the rami of the mandible. The inner, opposed, margins of these plates are straight, the outer, evenly convex.

The *hyoidean arch* is strong and well ossified, and is connected with the hyomandibular by a very strong "*stylo-hyal*" *St. h.*, figs. 3 and 6, Pl. VII. [Plate 7]).

Each *branchial arch* is, apparently, a single arcuated bone, deeply grooved posteriorly. I can count only four on each side in the specimen (belonging to the Earl of Enniskillen), which best displays these structures.

The resemblance of the branchial apparatus of *Macropoma* to that of *Cœlacanthus* is still further increased by the large spatulate bone,

[1] In No, 25,872, of the British Museum Collection, the surface of the jugular plates is perfectly preserved, and is ornamented with tubercles of enamel, which are set, evenly, and pretty close together, over its whole surface.

which in *Macropoma*, terminates the median part of the branchial skeleton posteriorly. No specimen has exhibited the anterior moiety of the median branchial skeleton, so that I am unable to say whether it has or has not the form of a crucial bone.

I have not been able to procure detached teeth of *Macropoma* for microscopic examination. The bases of even the largest teeth are perfectly smooth, and present no longitudinal grooves or foldings.

Macropoma substriolatum, Huxley (Plate IX. [Plate 9] and X. [Plate 10]).

I have abstained hitherto from referring to a specimen of a fossil fish to which Sir Philip Egerton refers in the following terms, in the note at p. 19 the " Preliminary Essay " of Decade X. :—

" In the Woodwardian Museum, at Cambridge, there is the head and part of the trunk of a *Cœlacanthus*, from the Kimmeridge clay at Cottenham. The head shows the frontals, prefrontals, and lower jaw, with the tympanic attachments. The glossohyal plate is double, as in *Holoptychius*. The scales are roughly undulate, coarser in pattern than in *Undina*, *Cœlacanthus*, and *Holophagus*, but not absolutely tuberculate, as in *Macropoma*. One fin is preserved, probably the left pectoral. It is lobate, broad, and strong. The operculum is triangular, the frontals short, and the prefrontals descend at an abrupt inclination."

Pl. IX. [Plate 9] represents the ventral surface of the body of the Cœlacanth fish of which Sir Philip Egerton speaks, of the size of nature.

It is covered with large, thin, cycloidal scales, each of which is divided into a large smooth region, overlapped in front and on each side by the neighbouring scales, and a comparatively small free part, which presents numerous close-set elongated dots, or short ridges of enamel. The dots and ridges are distinct, and their long axes are roughly parallel with that of the body, though the lateral ones sometimes show a certain tendency to diverge from the long axis of the scale itself.

The left pectoral fin (*P*) is very well shown, and exhibits, at fewest, fifteen fin-rays, the bases of which are so disposed as to inclose an oval "lobe," which is completely covered by small scales, not more than half, or a third, as large as those of the body, but possessing the same ornamentation.

The proximal ends of the fin-rays are unarticulated, but seem to be hollow ; distally they become broader and flatter, and then narrow to points, without becoming longitudinally subdivided. Rather more

than the distal half of each, apparently, was divided, transversely, into short broad joints.

The surfaces of these fin rays are quite smooth.

Four views (one-half the size of nature) of the head of this fish are given in Pl. X [Plate 10]; it is composed of a parieto-occipital and a frontal moiety, as in *Macropoma*, and the former (*Pa*) is divided by a median suture into two. The frontal shield is greatly crushed, and its precise form cannot be made out, but so much of it as remains is like that of *Macropoma*.

The general arrangement of the suborbital bone or bones (figs. 2 and 3) is plainly similar to that in *Macropoma*; and the same likeness extends to the operculum (*Op*), to the strong pulley-like end of the quadrale (*Qu*),—divided in the present fish by a longitudinal depression, so as to resemble the articular end of a phalanx,—and to the lower jaw.

I suspect that *b*, fig. 2, represents the *post-maxillary* bone of the Chalk *Macropoma*, in which case the flat bone *a* (figs. 2 and 3) will probably be the *suboperculum*.

The jugular bones (fig. 4, *G*) are double, and closely resemble those of *Macropoma* in form: they present an ill-defined rugosity, but no proper sculpture, and no trace of enamel, resembling in this repect the opercula and the other bones of the head.

At *a*, fig. 4, clear traces of ossified branchial arches are visible.

In its general characters it is clear that this fish completely resembles *Macropoma*; and considering the frequency with which the enamel is found to have disappeared from the cranial bones of fishes of the latter genus in the Chalk, no weight can, I think, be attached to this apparent difference.

The scales are quite similar to those of *Macropoma* in form and in the proportion of the sculptured to the unsculptured part (the unsculptured part in the scale 3 of plate 65 *b* of the "Recherches" is far too small), but the enamel tubercles are far less regularly oval and tend to become elongated and ridge-like.

I think, therefore, that this may safely be regarded as a distinct species, for which I propose the name of *Macropoma substriolatum*.

I am indebted to Professor Sedgwick and Mr. H. Seely, for the opportunity of figuring and describing the specimen on which this species is based.

The common characters, classification, and distribution of the CŒLACANTHINI.

The fossil fishes which have been described above under the names of *Cœlacanthus*, *Undina*, *Holophagus*, and *Macropoma*, have the following characters in common :—

1. The body is covered with thin cycloidal scales, the exposed portion of which is ornamented with tubercles or ridges of enamel.

2. There are two dorsal fins, the anterior supported by a single broad and plate-like interspinous bone; while the posterior has a forked interspinous bone. There is a single anal fin, and a very large caudal, the upper and lower lobes of which are equal; the spinal column, which traverses it without being at all bent up, ending in a filament with small supplementary fin-rays.[1]

In the caudal fin, interspinous bones are interposed between the fin-rays and the neural and subvertebral spines.

The paired fins are obtusely lobate. The pectoral arch is strong and well ossified, and there are two large pelvic bones. The fin-rays of all the fins are not articulated at their proximal ends, and are longitudinally undivided. The ventral fins are placed but very little behind the anterior dorsal, and the anal lies below the posterior dorsal.

4. The spinal column is unossified, the notochord being persistent and only the neural and subvertebral arches ossified. If ribs existed at all, they were remarkably small.

5. The roof of the skull is formed by a parieto-occipital and a frontal shield, which meet at an obtuse angle. The surface of each of these is ornamented with tubercles of enamel.

6. There is a large "pterygo-suspensorial" bone representing the hyomandibular, quadrate, and pterygoid bones of ordinary fishes.

7. There are two jugular bones and no proper branchiostegal, rays.

8. The branchial and hyoidean arches are well ossified, and there is a median bone in the branchial series which has a spatulate posterior termination (not observed in *Holophagus* and *Undina ?*).

9. The air bladder has ossified walls.

13. The teeth are for the most part "en brosse" or tubercle-like and minute; but a few are larger, acutely pointed (*Undina ? Holophagus ?*). These larger teeth exhibit no plications at their bases.

[1] This peculiarity of the caudal fin has not been actually observed in *Macropoma*; but it is hardly doubtful that the cretaceous genus resembled the others in this particular.

These being the common characters of the *Cœlacanthini*, the next point is to obtain clear definitions of the several genera which compose the group.

Cœlacanthus is readily enough distinguished from the rest by the ornamentation of its scales, which is disposed in converging ridges, not in tubercles; by the ridged ornamentation of the rami of the mandible and of the jugular bones; and by the absence of spines upon the fin-rays of the median fins.

In *Macropoma*, on the other hand, the scale ornament is made up of distinct tubercles; the jugular bones and mandibular rami are covered with tubercles, not with ridges; there are single or double rows of stout spines upon the anterior edges of the fin-rays of the median fins, which are inarticulated through the greater part of their length.

In *Holophagus* the scale ornament is in ridges, like that of *Cœlacanthus*. There are small spines, sometimes in more than two rows, upon the fin rays of the anterior dorsal and both lobes of the caudal fins; but I see none upon the second dorsal or upon the anal. The median fin-rays are articulated through more than half their length.

Of the two species of *Cœlacanthus* (= *Undina*) described by Count *Münster*, *C. Kohleri* is distinguished by the ornamentation of its scales "resembling flies' eggs," and by the rows of small spines upon the fin rays of the first dorsal and caudal fins.

The beautiful specimen of this species, the property of the Earl of Enniskillen, which is before me, shows the first and second dorsal fins, the pectoral, and the ventrals; the tail is wanting. The fin-rays of the anterior dorsal are spinous, and the spines are set in a double row along the anterior edges of the fin-rays, much as in *Macropoma*, and unlike *Holophagus*. The fin-rays remain undivided much further from their base than in *Holophagus*, and in this respect, also, more resemble *Macropoma*.

The sculpture has disappeared from the cranial bones, and the inner sides of the two jugular bones are exposed, so that nothing can be said upon this point. The scales are represented by mere bony films.

The head is altogether similar in form to that of *Macropoma*. There is a well ossified parasphenoid. The stylohyal, the operculum, the pectoral arch, and the lower jaw, so far as they are preserved, are very like those of *Macropoma*.

The only teeth which are visible are small and granular, and resemble those of the pterygo-suspensorial and parasphenoid bones

ptopomus

in *Macropoma*. The absence of pointed teeth is a circumstance of merely negative import, to which I am not disposed to attach any importance.

Of *Cœlacanthus* (*Undina*) *striolaris* I have seen no specimen, but while Münster's figures show that, in all important respects, it resembled *C. Kohleri*—he assigns to it scales with a striated ornamentation, and fin-rays without spinous ornamentation. Putting aside the teeth (the absence of sharp teeth in *Undina* and of granular teeth in *Cœlacanthus* not being proved), I see no character by which this species is separable from *Cœlacanthus*, while *C. Kohleri* appears to be equally indistinguishable from *Macropoma*.

If this supposition should be borne out by the examination of more perfect specimens of *Undina*, the genera of Cœlacanths would be reduced to three,—*Cœlacanthus*, *Holophagus*, and *Macropoma*; and, in the ornamentation of its scales and fin-rays, *Holophagus* would occupy the same intermediate position between the other two genera as it does in time. However, it is better, for the present, to retain *Undina* as a distinct genus.

Bearing in mind the range of the Cœlacanths from the Carboniferous to the Chalk formations inclusive, the uniformity of organization of the group appears to be something wonderful.

I have no evidence as to the structure of the base and side walls of the skull in *Cœlacanthus*, but the data collected together in the present Decade show that, in every other particular save the ornamentation of the fin-rays and scales, the organization of the Cœlacanths has remained stationary from their first recorded appearance to their exit. They are remarkable examples of what I have elsewhere termed "persistent types," and, like the Labyrinthodonts, assist in bridging over the gap between the Palæozoic and the Mesozoic Faunæ.

DESCRIPTION OF PLATES.

PLATE I. [Plate 1].

Fig. 1. The cast of a specimen of *Glyptopomus minor*. In Dr. Taylor's Collection. *Nat. size.*

Fig. 2. The skull of a larger *Glyptopomus* viewed from above. It is described in Decade X. "Introductory Essay," p. 4. In the British Museum. *Two-thirds of the size of nature.*

Fig. 3. A fragment showing the sculpture of the jugular plates (*G*) and the mandible (*Mn*). In the Museum of Practical Geology. *Nat. size.*

Fig. 4. A slab with well preserved scales and a tooth of *Glyptopomus*. *Nat. size.* The tooth and one of the scales are represented separately and magnified.

PLATE II. [Plate 2].

Fig. 1. A specimen of *Cœlacanthus lepturus*, of the natural size. In the Museum of Practical Geology.

Fig. 2. The anterior part of the body enlarged.

Figs. 3, 4. Scales magnified.

PLATE III. [Plate 3].

Fig. 1. *Cœlacanthus lepturus*, of the natural size.

Fig. 1*a*. Scales magnified.

Fig. 1*b*. Part of the ornamentation of the operculum magnified.

Fig. 2. The hinder part of the body of a *Cœlacanthus lepturus*, of the natural size, showing the remains of the ossified air-bladder.

Fig. 3. Under view of the head of a *Cœlacanthus lepturus*.

All these specimens are in the Museum of Practical Geology.

PLATE IV. [Plate 4].

Fig. 1. Magnified view of the counterpart of the specimen represented in Plate III. [Plate 3], fig. 3.

Fig. 2. The mandible of the same inverted.

Fig. 3. Under view of the head of a specimen in the collection of Edw. Binney, Esq., F.R.S.

Fig. 4. Pelvic bones of *Cœlacanthus lepturus*. In the Museum of Practical Geology.

Fig. 5. The two dorsal fins of a *Cœlacanthus lepturus*. In the Museum of Practical Geology.

Fig. 6. Caudal extremity of a specimen of *Cœlacanthus lepturus*. Magnified 1½ times.

PLATE V. [Plate 5].

Figs. 1, 2, 3, 4. *Cœlacanthus elegans*. From specimens in the collection of Sir Philip Egerton, Bart.

Fig. 5. *Cœlacanthus caudalis*. In the collection of Sir Philip Egerton, Bart.

Figs. 5, 6. *Cœlacanthus elongatus*. In the Museum of the Geological Survey in Ireland.

PLATE VI. [Plate 6].

Holophagus gulo, with a scale and fin-rays magnified. In the Museum of Practical Geology.

PLATE VII. [Plate 7].

Fig. 1. *Macropoma Mantellii*. One-half of the size of nature. In the Museum of Practical Geology.

Fig. 2. A detached air-bladder of *Macropoma Mantellii*. One-half the size of nature. In the British Museum.

Fig. 3. The head of *Macropoma Mantellii* figured by Prof. Agassiz, 'Recherches,' II., Pl. 65*d*, fig. 2, the matrix having been further cleared away.

Fig. 3*a*. The teeth enlarged. In the British Museum (No. 4,237).

Fig. 4. A side view of the snout of the *Macropoma Mantellii*. Figured by Prof. Agassiz, *l.c.*, Fig. 1. In the British Museum (No. 4,270).

Fig. 4*a*. Front view of the dentigerous "premaxillary" bone. Magnified.

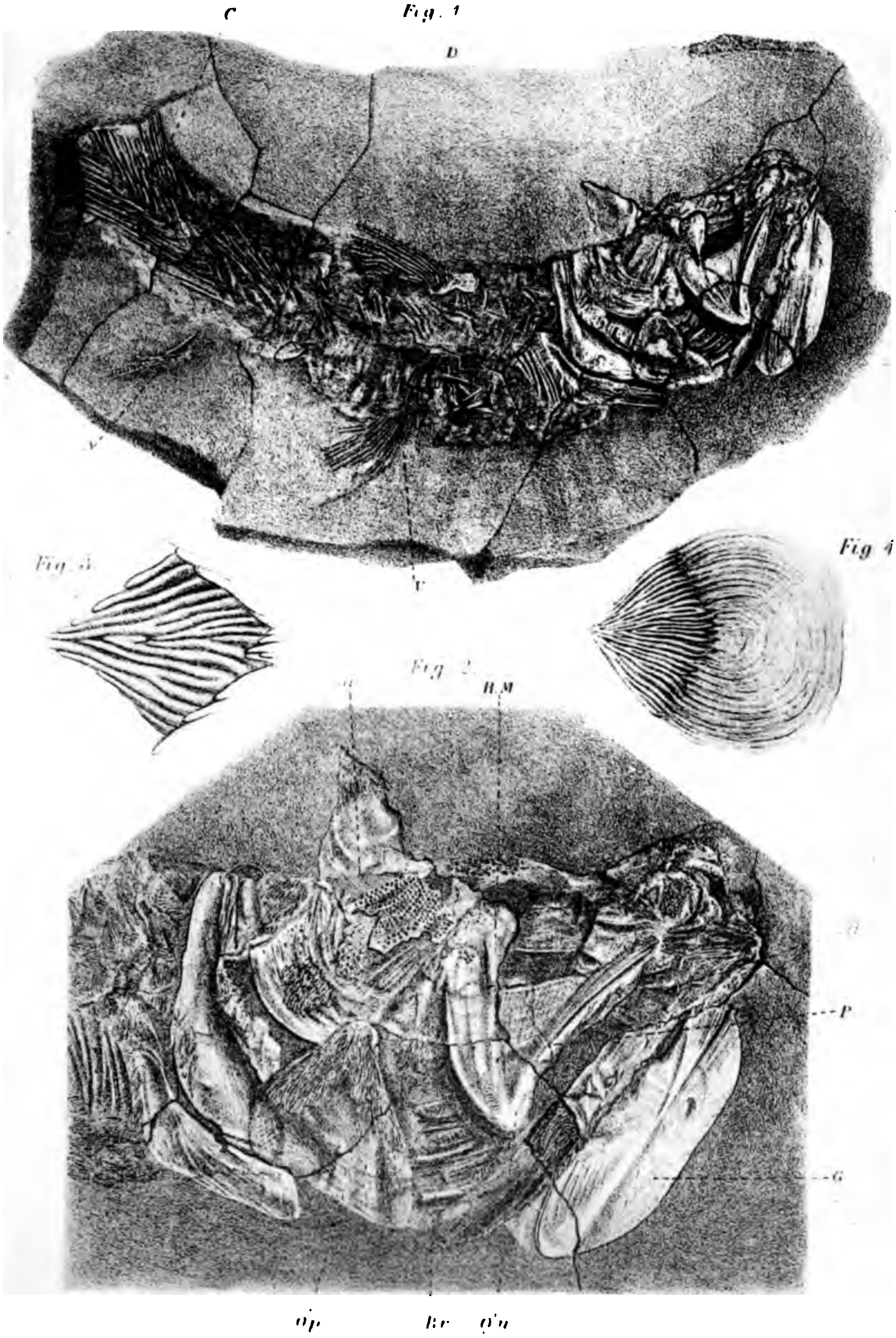
Fig. 4*b*. The upper end of the pectoral arch of this specimen.

Fig. 5. A pectoral fin of a *Macropoma Mantellii*. In the British Museum (No. 4,258).

Fig. 6. The head of a *Macropoma Mantellii*. Figured by Prof. Agassiz, *l.c.*, Fig. 3. In the British Museum (No. 4,252).

[PLATE 2.]

Geological Survey of the United Kingdom. DECADE XII. PLATE II

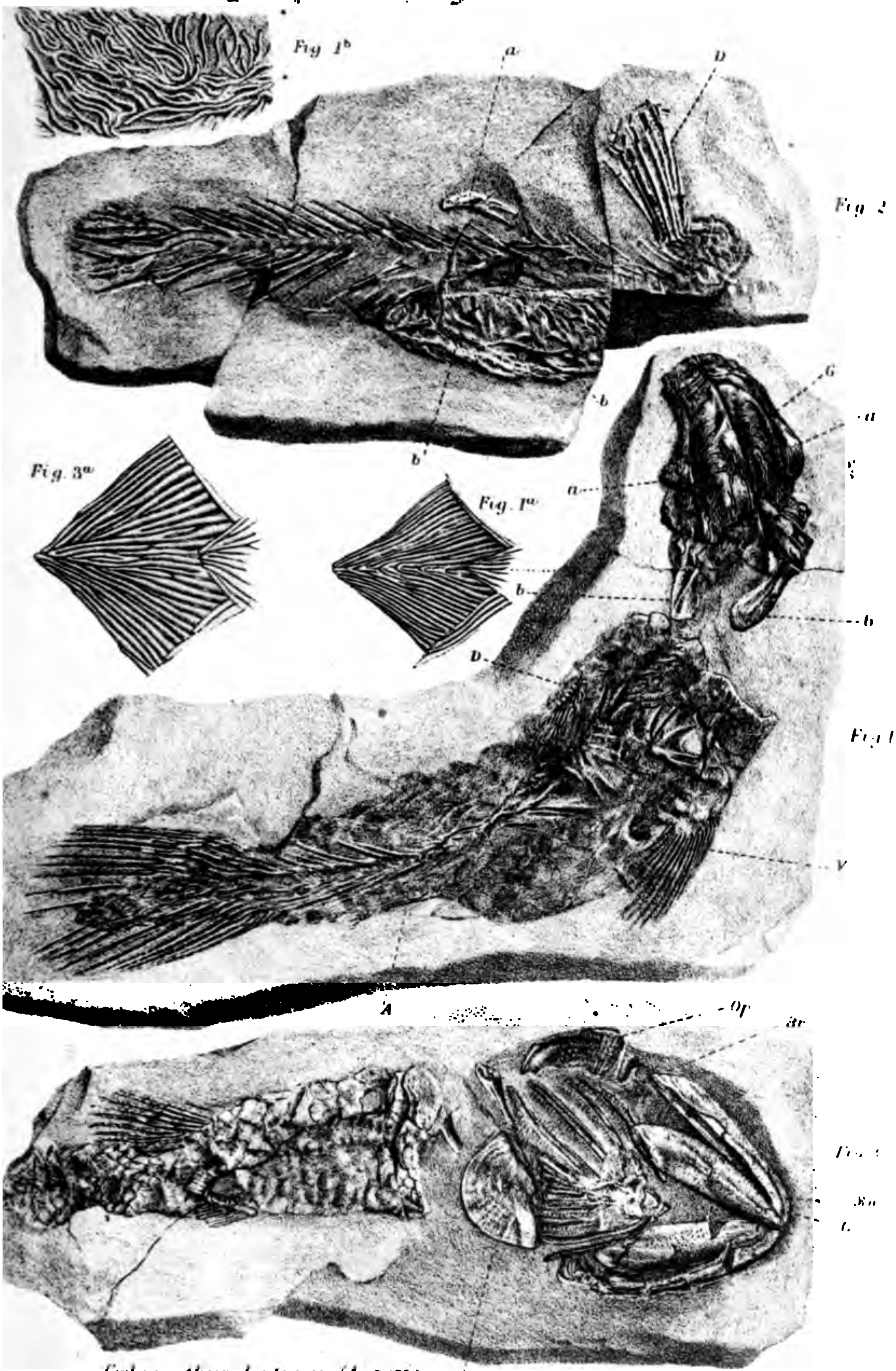


[illegible] lepto[illegible] Agassiz

[PLATE 3.]

Geological Survey of the United Kingdom.

DECADE X[illegible]



Coelacanthus lepturus (Agassiz

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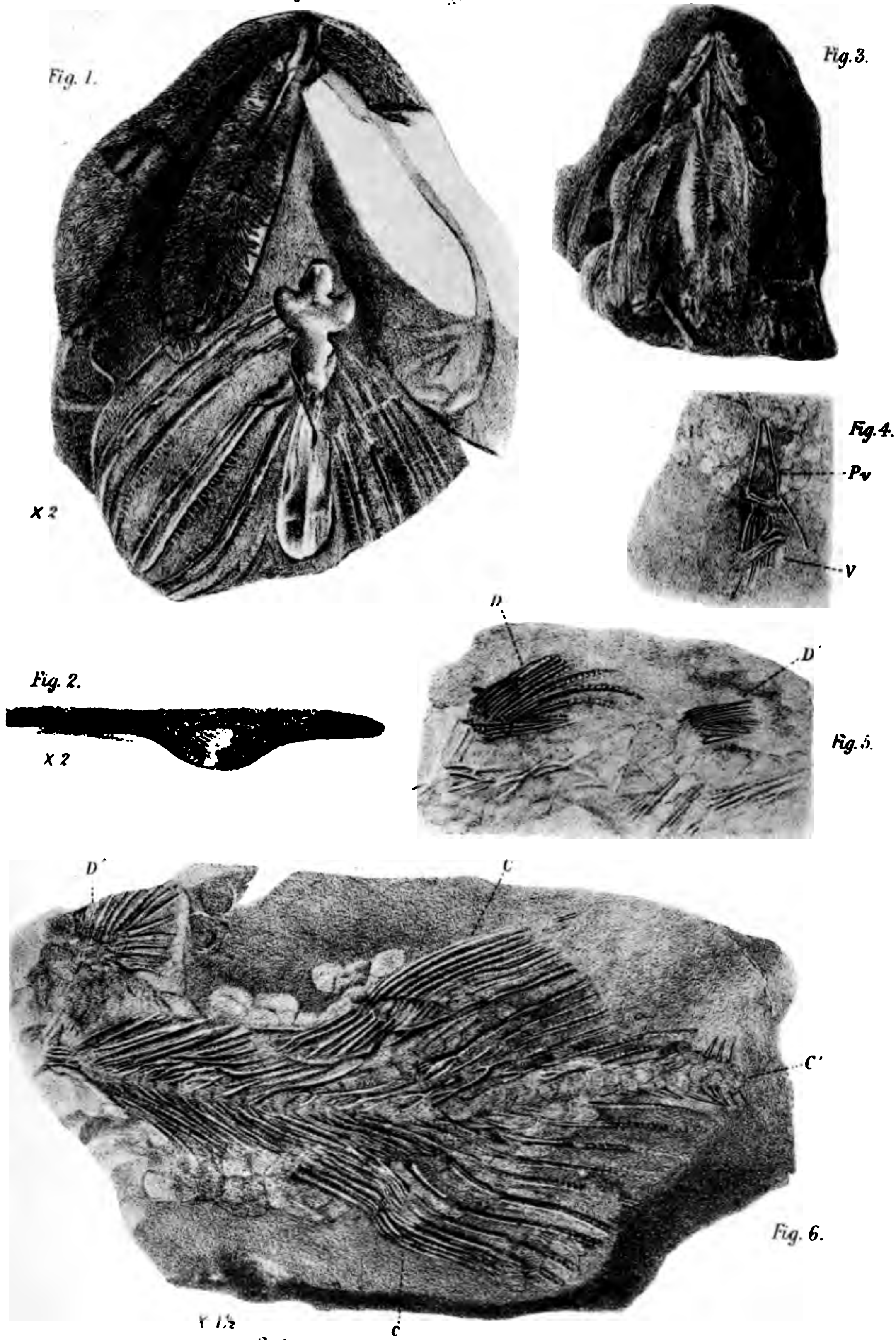
[PLATE 4.]

Geological Survey of the United Kingdom

DECADE XII. PLATE IV.



Cœlacanthus Lepturus (Agassiz.)

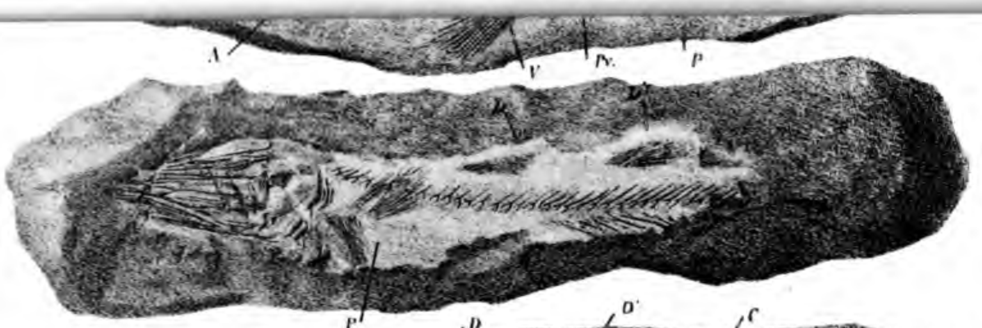


Fig. 6

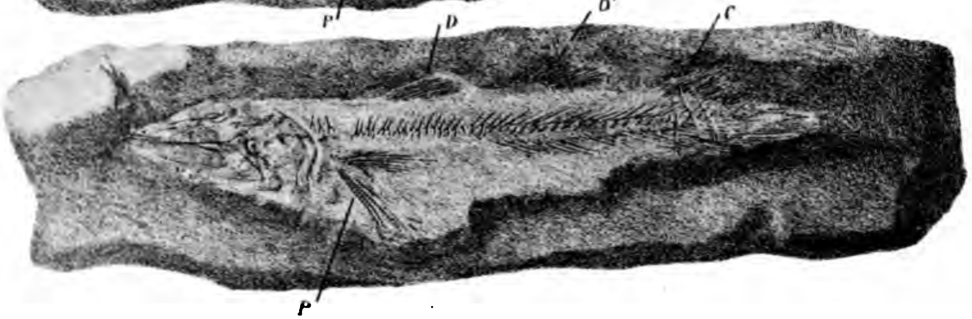
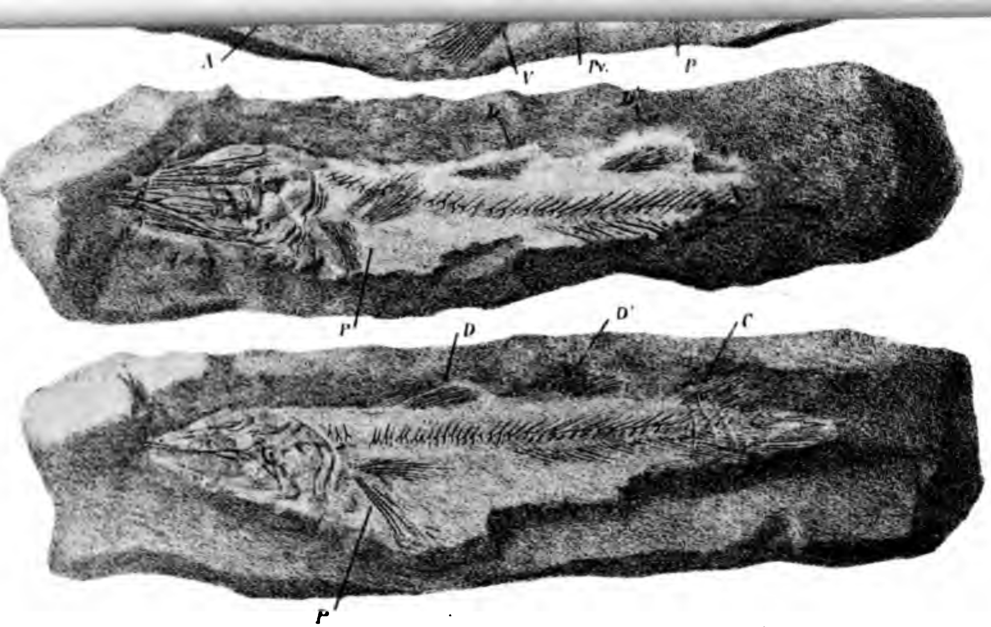


Fig. 7

Cœlacanthus elegans (Newberry) Figs 1 4.
Cœlacanthus caudalis (Egerton) Fig. 5.
Cœlacanthus elongatus (Huxley) Figs 6_7.

Fig. 6

Fig. 7

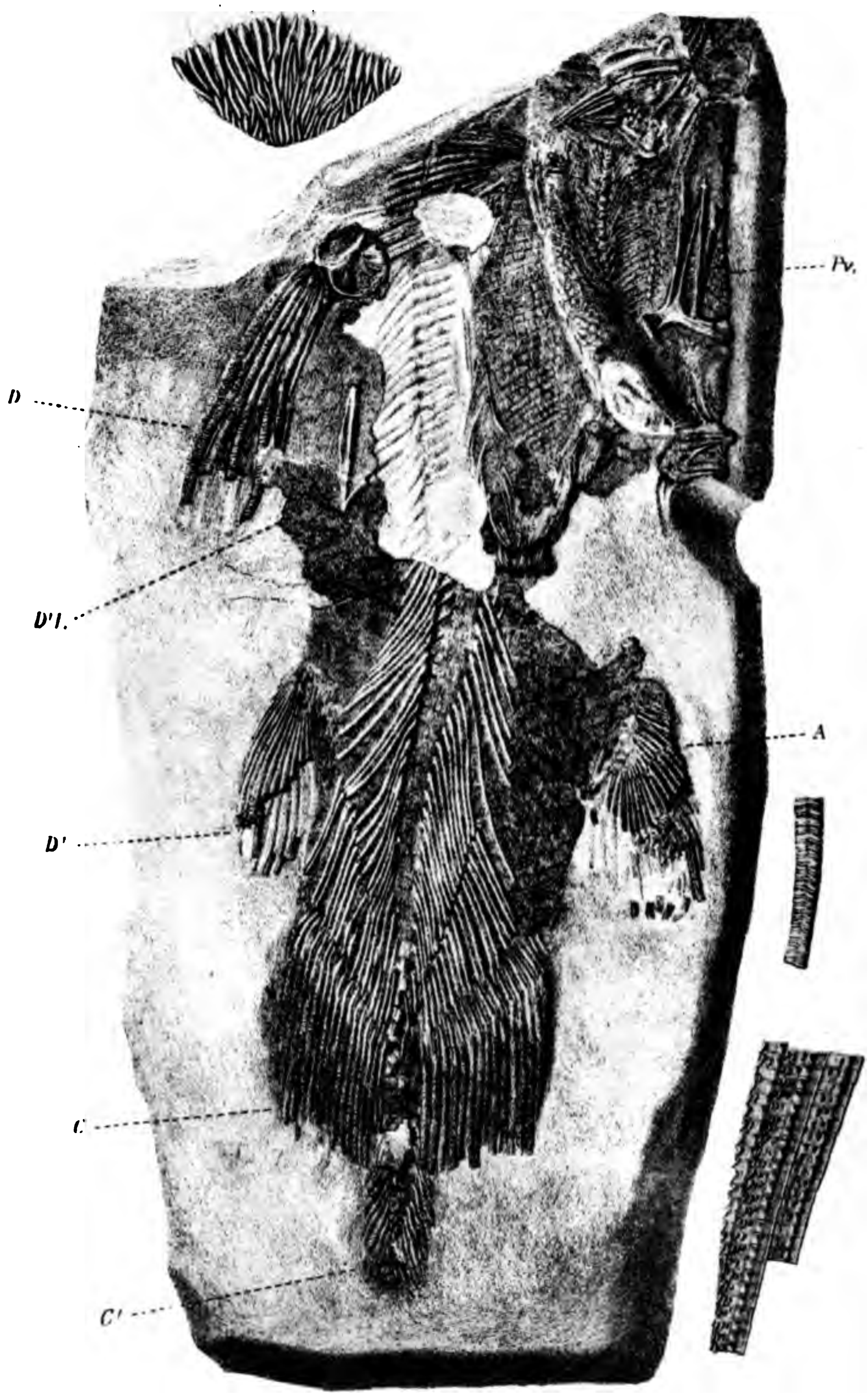


Cœlacanthus elegans (Newberry) Figs. 1 4.
Cœlacanthus caudalis (Egerton) Fig. 5.
Cœlacanthus elongatus (Huxley) Figs. 6 _ 7.

[PLATE 6.]

Geological Survey of the United Kingdom.

DECADE XII. PLATE VI



Holophagus gulo. (Egerton.)

[PLATE 7.]

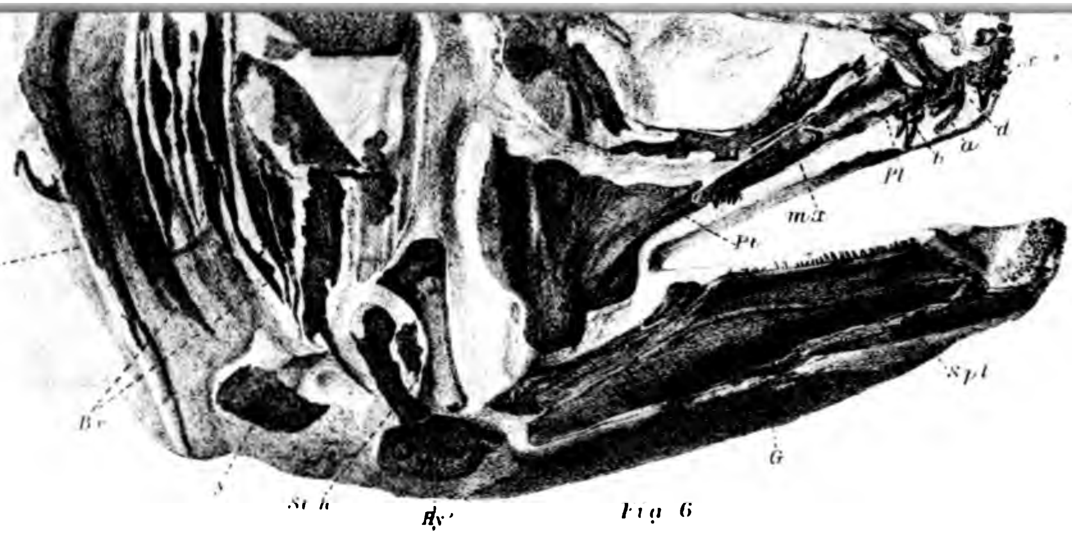


Fig. 5

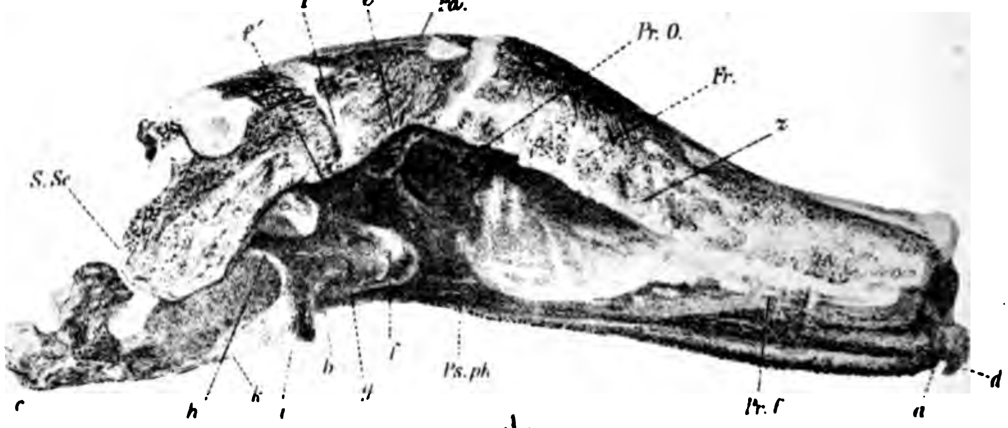
Fig. 6

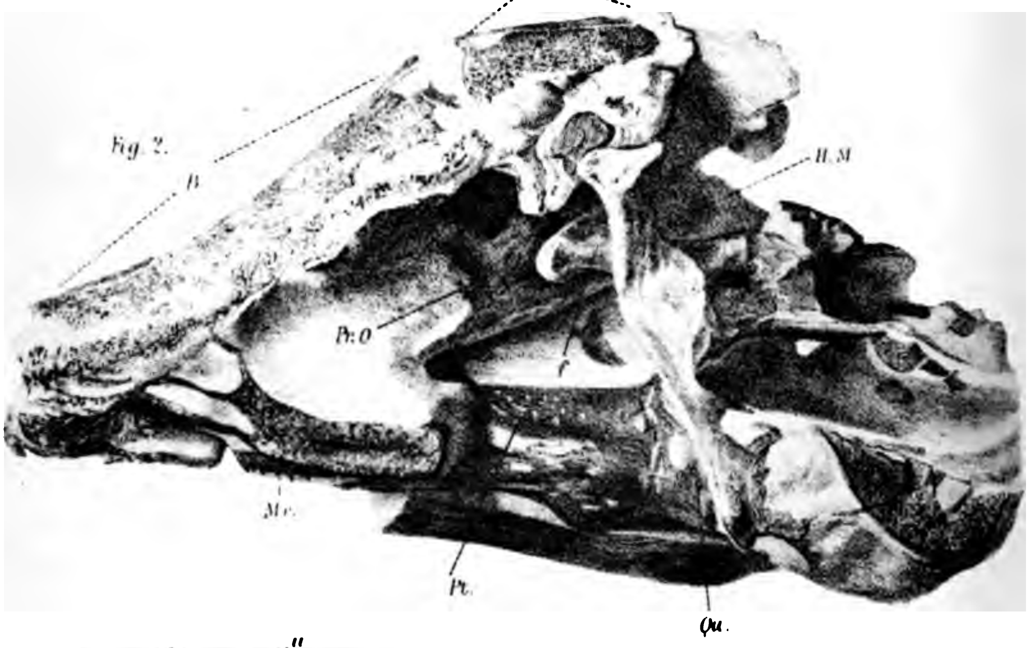
Macropoma Mantelli, Agassiz

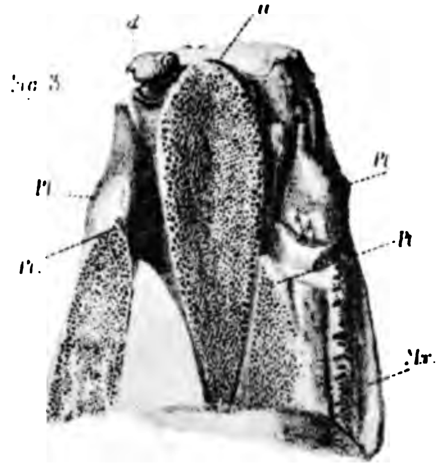
Geological Survey of the United Kingdom

DECADE XII. PLATE VIII.

Fig 1

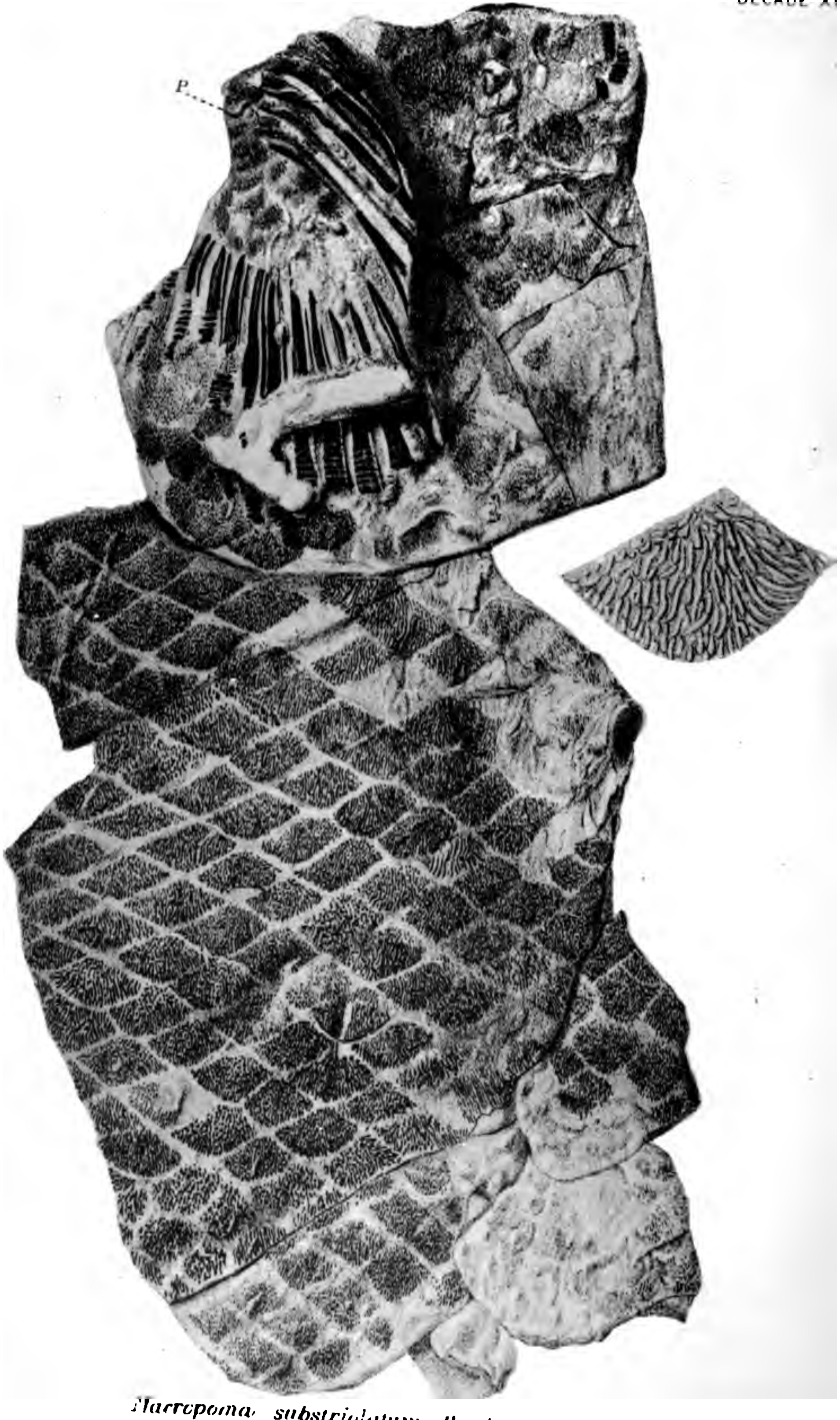






Macropoma Mantelli. (Agassiz.)

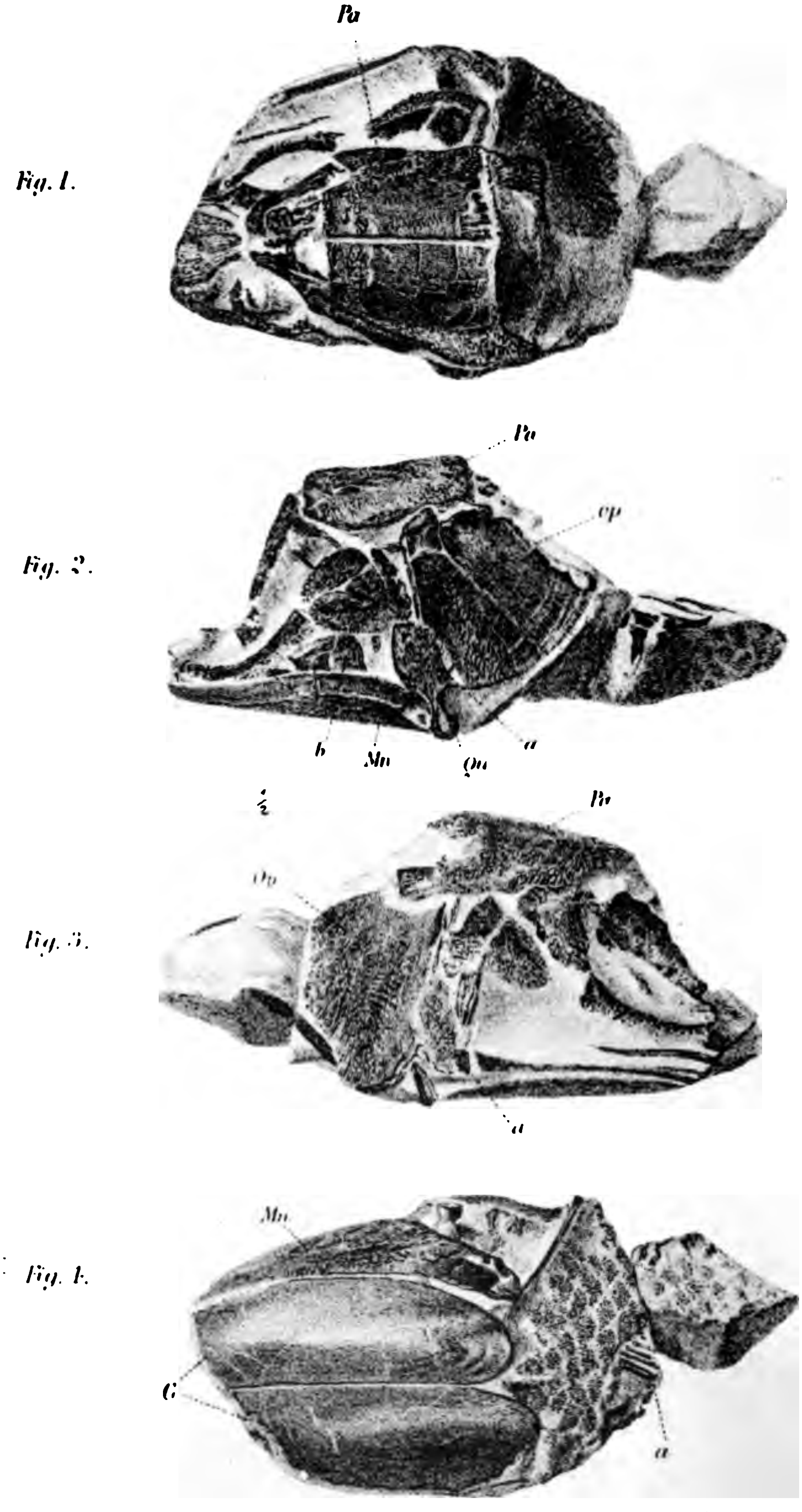
Geological Survey of the United Kingdom.



Macropoma substriolatum, Huxley

[PLATE 10.]

Geological Survey of the United Kingdom. DECADE XII. PLATE



Macropoma Substriolatum (Huxley.)

PLATE VIII. [Plate 8].

The skull of a *Macropoma Mantellii*. In the collection of the Earl of Enniskillen.

Fig. 1. A view of the right side ; Fig. 2, of the left side ; Fig. 4, from behind.
Fig. 3. The under surface, so far as the matrix allows it to be seen.

PLATE IX. [Plate 9].

The body of *Macropoma substriolatum*, with a single scale, magnified. In the Woodwardian Museum, Cambridge.

PLATE X. [Plate 10].

The head of the same specimen from above (Fig. 1), the sides (Figs. 2 and 3), and below (Fig. 4). One-half of the size of nature. In the Woodwardian Museum, Cambridge.

III

BRITISH FOSSILS

Decade XIII. Plate X. [*Plate* 11].

Memoirs of the Geological Survey of the United Kingdom. 1872.

Holophagus gulo. The specimen in the Museum of Practical Geology, upon which the genus *Holophagus* was founded (Decade XII., p. 26, Plate VI. [Plate 6]), lacks the head and the pectoral fins; but, by the kindness of the Earl of Enniskillen, I am enabled to supply this deficiency, and to figure the very fine, and almost entire, example of the genus represented in Plate X. [Plate 11], of one-half the size of nature.[1]

The parts of the body which can be compared show the entire concordance of this specimen with the type.

In addition, the characteristically ossified air-bladder is well displayed, a few short ribs lying above its posterior third.

Between the ventral and the anal fins there lies a strong forked bone, which seems to have supported the anal fin. In its general form, and in the configuration of its constituent bones, so far as they admit of comparison, the skull is extremely like that of *Macropoma*, and, as in the latter fish, the ornamentation consists of dots of enamel. Indeed, it is hard to say by what character, except the greater extent to which the dorsal fin rays are articulated, *Holophagus* is distinguishable from *Macropoma*.

As the figure shows, there is an appearance as if ossified vertebral centra were developed in the most anterior part of the spinal column. What the elevations thus represented really are, it is not easy to say, but comparison with the thickness of the notochord will show that they are not nearly large enough for true centra.

The specimen figured could not, when entire, have been less than 30 inches long. The head, from the occiput to the snout, measured about 7 inches. It was obtained from the Lias of Lyme Regis.

[1] As the drawing has not been reversed, it is the right side of the fish which is depicted.

G

IV

THE REDE LECTURE

Nature, vol. xxviii., 1883, *pp.* 187-189. *Read May* 12, 1883.

THE following abstract report of Prof. Huxley's Rede Lecture, given on Tuesday week in the Cambridge Senate House, to a crowded audience, has been revised, to the extent of removing any errors of importance, by the author.

Professor Huxley said he had undertaken to treat in the course of such time as custom and the patience of his audience might permit, on a very great subject, no less a subject than the origin of all those forms of animal life which at present existed. It had behoved him to restrict what he might lay before them to those considerations which were absolutely essential for his purpose, and he should endeavour to lay before them facts of such an order as appeared to him to be of most importance in reference to his argument. Although he might fail to put those facts before them as clearly as they presented themselves to his own mind, the reasonings which might be based upon them were of so simple an order that he should consider his task performed if he gave them a tolerably clear conception of what those facts were, for he did not think it was the business of a man of science to use the arts of rhetoric or endeavour to procure persuasion. His sole business was to place the facts before those whom he wished to teach, and to leave it to their reason to form such judgment upon those facts as they might think fit. In the present case he should point out to them what judgments such facts had forced upon his mind, but he must leave it entirely to their responsibility to say what judgment they might constrain them to give in their case. They might assume this position at starting, that, whatever in such a matter was true for one animal, was true for the infinite series of the whole animal world ; and as he was extremely anxious to avoid everything speculative, everything that could not be directly led back to the matters of fact upon which

it was based, he proposed to select one animal particularly, and to put before them facts and arguments by the help of which they might form some probable conclusion as to the origin of that object. He took it for granted that, if the evidence inclined towards a particular conclusion in the case of that animal, they might assume that it would incline in the same direction with regard to all. He had no doubt that a great many of his audience were familar at any rate with the shell of the animal about which he was going to speak, namely, that of the pearly nautilus, from which, or parts of which, very beautiful ornaments were fabricated. At the present time the nautilus inhabited the warmer parts of the Indian and Pacific Oceans, living at considerable depths and preying upon the hard-shelled crustaceans and mollusks that crept along the bottom, and which it found in its way. For that end it was provided with a very curious beak, shaped like that of a parrot, but with each portion covered with a hard calcareous deposit, and which enabled it to be an efficient instrument for crushing its prey. If he were to touch upon the morphological problem which here presented itself, he could occupy far more time than they had at their disposal with the consideration of a multitude of interesting peculiarities which the nautilus presented, for it was one of those forms which at present stood almost isolated and alone in the animal world, separated by a wide gulf from its nearest allies, those animals which they knew as squids and cuttle-fishes. It held the middle place between sea-snails and the group of the cuttle-fishes. It would be, however, entirely out of place at present, and a purposeless waste of time, if he were to touch upon any peculiarities except those which would be needed during his further argument. The only points to which he would direct their attention for that purpose were the facts which related to the structure of the shell. There was a diagram beside him showing a part of the nautilus shell in section, but he thought it possible that he could make the matter clearer by roughly sketching on the board the main points as he went on.—Prof. Huxley here described, with the aid of diagrams, preserved specimens, and models, the complicated structure of the shells of the pearly nautilus, or *Nautilus pompilius*. The animal itself was contained in the spacious chamber in the outer part of the shell, which was divided from the rest of the shell by a partition. The rest of the shell resembled a long cone closely coiled up, and divided by partitions at regular intervals into other chambers, which succeeded one another, and in the full-grown animal were full of air. From the hinder part of the animal's body a long tube, the siphuncle, was carried backwards through the whole of the shell, and as it completely filled up the open-

ings in the partitions through which it passed there was no communication between one chamber and another. The first point to be considered was as to what was the origin of the particular nautilus in the bottle before him. Happily there was no dispute upon that point. The female nautilus contained eggs exactly as the hen did. These eggs were small masses of protoplasmic matter, each containing a nucleus in its centre, which was all that was essential. They knew that that pearly nautilus with all its complicated organism, and fitted with the complicated shell he had described, did, in some way or other, proceed from that relatively structureless body which they called the egg or the ovum. As fate would have it, up to the present they had known nothing from direct observation of the process by which that particular animal was produced from this microscopic particle. But they had so large a knowledge of the process in other animals of every description that there was no doubt whatever as to the nature of the process, which he would try to describe to them as briefly as possible, by reference to the process which took place in the case of the domestic hen. Neither by the highest powers of the microscope, nor by other means of investigation which they had at present, could they trace anything in the slightest degree resembling either the chick, which under certain circumstances proceeded from that egg, or the tissues of the chick. There was, however, one spot on the yolk of the egg, a little careful observation of which would show a clear space, which might be a fifth of an inch in diameter. It was very well known by the name of the cicatricula, or little scar. He would suppose that twenty-one eggs were placed together under the hen. If they took one egg day by day and examined it they would know what took place as if they had watched continuously, for what happened in any one egg happened also in the others. That was a process—the wonder of which he must confess never staled in his mind—by which the chick was gradually fashioned out of that transparent rudiment. They saw it make its appearance in the first place on the surface of the yolk, and to the naked eye it looked like a white streak. That white streak gradually assumed the appearance of a sort of elongated body, and that body shaped itself so that it could be seen that it was going to be an animal of some kind, it having a large head, and the rudiments of eyes and vertebræ. On the fifth day they could clearly see what they were going to have. Gradually, step by step, and moment by moment, new differences made their appearance from the original foundation, and until many days before hatching there was an unmistakable bird, and at the twenty-first day there emerged from the shell an animal endowed with all a bird's capacities

and structures. That process was the process of development. If they inquired into the nature of the cicatricula, they would find that that was merely a double layer of minute nucleated cells. They would find that that resulted from the splitting up of a protoplasmic mass that had been there before. They could trace the process back into the body of the hen until they came down to a simple nucleated cell, so that it was a matter capable of demonstration that in that nucleated cell which formed a part of the egg organ of the hen—in that particle of, for morphological purposes, structureless jelly, were the same characteristics which were possessed by the very lowest forms of animal life which were known. They knew that in that particle resided a potentiality, capable of developing itself through the stages he had roughly indicated, until it became not only a machine of the highest order from a physiological point of view, but a very remarkable work of art. That particle of protoplasmic matter did that in virtue of the powers inherent in its material nature. That was the point he wished to put before them as clearly and definitely as he could, because it would be fundamental in all further discussion. For it was to the process he had briefly described that the great discoverers of the last two centuries applied the name of "evolution." Singularly enough the persons who first used that name did not use it in that sense in which it was universally used now, because they were under a mistake as to the exact nature of the process. But the whole conception of evolution was now based upon ascertained facts, showing the process of development of the most complicated animal out of a relatively structureless particle, which had no higher organisation than that of the lowest animal they knew, a process which progressed step by step by means of the gradual addition of small differences, until the animal attained its perfect form. That was what was meant by the process of evolution. At this point he thought it might be desirable that he should deal with what he might speak of as the *a priori* objections to the doctrines of evolution. He had had opportunities of making extensive acquaintance with those objections during the past twenty years or so. He divided them into three categories: (1) That evolution was impossible; (2) that it was immoral; and (3) that it was opposed to the argument of design. Now that was a very heavy indictment, but he thought they must plead "not guilty" upon all three counts. It required no great amount of reasoning to convince one that that which happened could not be impossible; that that which happened thousands and millions of times every hour and every minute in this world as it now was, under certain conditions, could not be held without further

evidence to be impossible under somewhat different conditions. Secondly, with regard to the question of morality. He had never understood that argument, and had always been disposed to reply that the morality which opposed itself to truth committed suicide. With regard to the argument of design he would not discuss that point himself, but would beg them to listen for a moment to words that would carry far more weight than any of his own could carry on that topic:—"The philosopher beholds with astonishment the production of things around him. Unconscious particles of matter take their stations and severally range themselves in an order so as to become collectively plants or animals, *i.e.* organised bodies with parts bearing strict and evident relation to one another and to the utility of the whole; and it should seem that these particles could not move in any other way than they do, for they testify not the smallest sign of choice, or liberty, or discretion. There may be particular intelligent beings guiding their motions in each case, or they may be the results of trains of mechanical dispositions fixed beforehand by intelligence or appointment and kept in action by a power at the centre." They might imagine, and not unreasonably, that those were the words of some ultra-evolutionist of the present day who desired to set himself right with the argument from design; but they were not so. They were more than eighty years old, and they were contained in the 23rd chapter of a book which was very much talked about, but, he was afraid, very little read, namely, the "Natural Theology" of Archdeacon Paley. When he was a boy that book was a very great favourite of his, partly for its own merits, and partly because it was one of the few books he was allowed to read on Sundays. He found it much more entertaining than most of the books included in that category. But from what had been since said of the Atheistic tendencies of the doctrine of evolution he began to think that he stood before them a miserable example of the manner in which a man's mind might be poisoned by early instruction, and that his incapacity to understand the force of the arguments against evolution arose from the circumstance that in his early childhood he was indoctrinated with the reasonings of a great divine of the Church.—Professor Huxley now proceeded to consider the next point, the coming into existence of the nautilus species in contradistinction from the origin of a particular nautilus as an individual. He showed that, according to all the evidence that could be gathered, there was every reason to believe the forms of animal life five thousand years ago were practically the same as they were now. If there were no other means of knowing anything about the history of animal life,

undoubtedly this experience, resting upon a duration of five thousand years, would have furnished an apparently sufficient basis for a generalisation, tending to the conclusion that the forms of animal life had not changed during that period. Not only had that generalisation been made, but it had been concluded that the forms of animal life were unchangeable, a totally different proposition, the validity of which rested, among other things, on the proportion between our actual experience, supposing it to extend over that time, and our possible experience of the duration of life on the globe. It would, he thought, be absolutely impossible for any of them, however good their vision, to say from actual observation of the hour hand of a watch for four seconds that it had moved during that interval, and in point of fact the space over which it would move was so minute as to be indiscernible, even through a magnifying glass. Yet they knew very well that it had moved, and if they watched it for four or five minutes, the evidence of its movement would be perfectly obvious, even to the naked eye. They would observe, therefore, that a period of observation which extended over the nine-hundredth part of an hour, would give them no conception from which it would be possible to draw a conclusion as to what had happened during the total period. Now geologists told them that the whole depth and extent of the fossiliferous rocks, which composed a considerable portion of the earth's crust, represented a period of time at least one thousand times as great as the historical period. That was a point upon which there could be no room for hesitation. Hence it followed that when they acquainted themselves with the succession of animal forms which were embedded at different depths in the earth's crust, they did exactly what the observer of a watch did when he kept his eyes fixed on it, not for four seconds, but for an hour, in which latter case the movement was not only conspicuous, but such as commonly served to indicate the lapse of time. If that analogy held good, the slow procession of events, which might be absolutely indiscernible in the course of 5,000 years, would become obvious and plain when the period of observation was extended to a thousand times that period. And that was exactly what happened, for if they went back in the series of stratified rocks they found the genus nautilus, which in the present day was represented by one or two species, represented in the long period of its history by many other species. As far back as the Upper Silurian formation the genus nautilus was represented by an abundant number of shells fabricated by animals having all the essential peculiarities which he had described. In the geological specimens before him, and which were taken from the rich collection

in the Woodwardian Museum, there were forms of nautili which no one doubted were to all intents and purposes the same in their general structure as the pearly nautilus of the present day, although they were at least 5,000,000 years old. Now came the main question: were those nautili whose history extended back through such a prodigious range of time identical in character with the modern species? So far as he knew there was nothing in the nature of things to show why a succession of generations which remained unchanged through 5,000 years should not remain so for 50,000 or 50,000,000 years. The facts, however, showed that there had been rather more than 100 distinct species of nautilus, each having as good a title to be called a species as *Nautilus pompilius* itself. No one of these species had endured for more than a portion of the duration of the whole genus, and many species had existed contemporaneously, those species, however, except perhaps two, were now extinct, so that now they were brought face to face with the heart of the question: by what hypothesis could they account for those phenomena? They were driven into hypothesis of some kind or other, because it was impossible to have any evidence of contemporary witnesses of facts which went so far back into the past. So far as he knew there were only two possible alternative hypotheses by which they could pretend to account for those facts. One of these hypotheses was what he ventured to call the hypothesis of construction. That hypothesis was that every one of those species was put together. It was making a needless difficulty to suppose that each species came out of nothing, because they knew that the body of the nautilus was made up of materials which were familiar to them in an inorganic state on the earth's surface; so that by the hypothesis of construction some agency had put together those materials a hundred times or so during the period that had elapsed from the formation of the Silurian rocks to the present day, as an artist constructed his work, or as a mechanician put together the parts of his machine. That was one hypothesis. For his part, he had not a word to say *a priori* against the possibility of that hypothesis. It was certainly conceivable and therefore, according to Hume's maxim, it was possible. But they must bring it, like all other hypotheses, to the test of facts and inquire how far it stood that test. He thought the hypothesis of construction presented two large and almost insuperable difficulties. The one was that it was absolutely opposed to everything that they had received traditionally concerning the origin of animal forms, and the second was that it was no less opposed to every doctrine which might reasonably be held upon grounds of sane science. It stood to

reason and common sense that they could have recourse only to those causes for the assumption of which there was some ground of analogy. The business of science would be extremely easy if for every event one were permitted to invent special causes having no analogy in nature. The difficulty of science was in tracing every event to those causes which were in present operation. That difficulty was being so constantly overcome that it had become a canon of physical science no less than it was a canon of historical science that speculation should confine itself to construing past events by the analogy of those of the present time. The hypothesis of construction seemed to him unacceptable, because it led them into contravention of tradition on the one side and into contravention of scientific logic on the other. The only other alternative hypothesis was that of evolution, which meant that the different forms of animal life had not arisen independently of each other in the great sweep of past time, but that the one had proceeded from the other; and that that which had happened in the course of past ages had been analogous to that which took place daily and hourly in the case of the individual. That was to say that just as at the present day in the course of individual development the lower and simple forms, in virtue of the properties which were inherent in them, passed step by step by the establishment of small successive differences into the higher and more complicated forms, so, in the case of past ages, that which constituted the stock of the whole ancestry had advanced grade by grade and step by step until it had attained the degree of complexity which was seen at the present day. No objection could be brought against this hypothesis on the ground of analogy, because in putting it forward they were not bringing in any kind of causation which was not abundantly operative at the present time. The question was whether the history of the globe in past time coincided with this hypothesis, and to that point he would next address himself. What did they find if they considered the whole series of these forms? Unquestionably, as he had said, nautili were found as far back as the Upper Silurian age. Before that time there were no nautili, but there were shells of the *Orthoceratidæ*—of which there were magnificent examples before him—which resembled those of the nautili in that they were chambered, siphoned, &c., with the last chamber of such a size that it obviously sheltered the body of the animal. He thought no one could doubt that the creatures which fabricated these still earlier shells were substantially similar to the nautili, although their shells were straight, just as the nautilus shell would be if it were pulled out from a helix into a cone. Then came the forms known as

the *cyrtoceras*, which were slightly curved. Along with these they had the other forms which were on the table, and in which the shell began to grow spiral. The next that came were forms of nautilus, which differed from the nautilus of to-day in that the *septa* were like watch-glasses, and that the whorls did not overlap one another. In the next series, belonging to the later palæozoic strata, the shell was closely coiled and the *septa* began to be a little wavy, and the whorls began to overlap one another. And this process was continued in later forms, down to that of the present day. Looking broadly at the main changes which the nautilus stock underwent, changes parallel with those which were followed by the individual nautilus in the course of its development, he considered that there could be no doubt that they were justified in the hypothesis that the causes at work were the same in both cases, and that the inherent faculty, or power, or whatever else it might be called, which determined the successive changes of the nautilus after it had been hatched, had been operative throughout the whole continuous series of existence of the genus from its earliest appearances in the later Silurian rocks up to the present day. What the whole question, in whatever way it might be put, came to, was this: Successive generations of animals were so many cycles of evolution that succeeded one another. Within the historical period, there was no doubt that, speaking roughly, those succeeding cycles had been identical, that was to say, without discernible difference. But when the period of observation became proportional to the slow rate of change they found, so to speak, that the hour hand had moved; for, in the successive cycles of evolution which had occupied the whole period, successive cycles had differed from one another to a slight extent. If they might assume that, then the whole of the phenomena of palæontology would fall into order and intelligibility. If not, they had to adopt an hypothesis which, as he had pointed out, had no support in tradition, and which was absolutely contradicted by every sound canon of scientific research. This was his case for evolution, which he rested wholly upon arguments of the kind he had adduced. From the time when he first read Charles Darwin's "Origin of Species," now some twenty-four years ago, his mind had fixed itself upon the tenth chapter of that book, which treated of the succession of forms in geological times, for it appeared to him that that was the key of the position; that if the doctrine of evolution was correct, the facts of palæontology, as soon as they became sufficiently known, must bear it out and verify it in every particular. On the other hand, he believed that, if the facts of palæontology or the historical facts of life on the globe were against

evolution, then all the rest of the argumentation in its favour would be vain and empty, because the difficulty of adopting it would be in that case absolutely insuperable. He would venture to repeat that the occurrence of evolution was a question of history. He did not know whether Sir Henry Maine was not more competent to speak on that point than he was. It was a question as to whether they would interpret the facts of animated nature scientifically, or whether they would open the door to every description of hypothetical vagary. He came to the conclusion that that was a point worth testing in every possible way, and for some twenty years he had given what leisure he had been able to beg, borrow, or sometimes steal, to the investigation of these questions. He had endeavoured to ascertain for himself how the doctrine of evolution fitted with the facts of palæontology with regard to the higher vertebrated animals, and with regard to the chief varieties of invertebrate animals, and all he could tell them was that the farther his own investigations had gone, the more complete had appeared to be the coincidence between the facts of palæontology and the requirements of the doctrine of evolution. The conclusion he had come to was that at which every competent person who had undertaken a similar inquiry had arrived, and if they would pay attention to the writings of such men as Gaudry, Rütimeyer, Marsh, Cope, and others, who had added materials upon which to form a judgment such as were not dreamt of when Darwin first wrote, they would find that they all without hesitation attached themselves to the doctrine of evolution as the only key to the enigma. In deciding the issue between the two hypotheses, serious inquirers would not trouble themselves about any collateral points as to the how and the why, or as to any of the subordinate points at issue. He thought he was entitled to entreat those who by their calling or by their position in society, or by the fact that they possessed any influence, might be led to express an opinion upon this matter, to look into the arguments which formed the foundation of the case for evolution. Happily, he might address that recommendation to members of the University of Cambridge with a perfectly good conscience, for at this present time he knew not where in the world any one could find better means of passing through all those preliminary studies which were essential to a comprehension of this great question, or where any one could find more amply displayed the means of testing the arguments which he had laid before them. He ventured to say that the members of this University were without excuse if they gave opinions on this question of evolution without having prepared themselves, by as diligent study as they would for

the purpose of approaching questions of literary or theological criticism, to express an opinion upon it. These were the considerations which he had wished to set before them that day. It would be understood that they would not suffice to enable any one to form a judgment upon the doctrine of evolution, but he hoped that they had sufficed, brief and insufficient as they were, to show that if judgment on this question was to be worth anything intellectually, if it was to be creditable to the moral sense of those who formed it, it would first be necessary that the facts should be clearly comprehended, and that the conclusion—whatever it might be—should be one which right reason would admit might be justly and perfectly connected with the facts.

V

INAUGURAL ADDRESS:

FISHERIES EXHIBITION, LONDON; 1883

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YOUR ROYAL HIGHNESS, YOUR EXCELLENCIES, MY LORDS AND GENTLEMEN,—It is doubtful whether any branch of industry can lay claim to greater antiquity than that of Fishery. Its origin would seem to be coeval with the earliest efforts of human ingenuity; for the oldest monuments of antiquity show us the fisherman in full possession of the implements of his calling; and even those tribes of savages, who have reached neither the pastoral nor the agricultural stages of civilization, are skilled in the fabrication and in the use of the hook, the fish-spear, and the net.

Nor is it easy to exaggerate the influence which the industry thus early practised and brought to a considerable degree of perfection has directly and indirectly exerted upon the destinies of mankind, and especially upon those of the nations of Europe. In our quarter of the globe, at any rate, Fishery has been the foster-mother of navigation and of commerce, and the disseminator of the germs of civilization.

Four thousand years ago, Europe was inhabited by tribes of intelligent savages whose social state stood in much the same relation to that of the polities on the banks of the Nile and the Euphrates, even then old, as that of the Polynesians did to the civilization of Europe a century ago.

But about, or perhaps before, that time certain tribes of Canaanites had built their huts on the shores of the Levant, and launched their canoes in search of the fishes which people the easternmost waters of the Mediterranean. The site of one of these fishing villages seems to

have especially adapted it to the purposes of fishermen, for they called it Sidon, which Semitic scholars tell us means "The Fishery." These enterprising people, animated by the genius for commerce, which then, as now, distinguished their race, set up a trade in dried and salted fish, which rapidly attained a considerable development. But their chief energies were devoted to the collection of a certain kind of mollusks, very similar to our common dogwhelks; and to the preparation from them of that famous Tyrian purple, which, from the richness and the variety of its hues, and from its wonderful stability, was prized more highly and sought after more eagerly than any other dye known to the ancients. Combining with this trade that in the metals, and especially in tin, these primitive corporations of Fishmongers gradually extended their operations, until they raised Sidon, and after the fall of Sidon, Tyre, to a position not less remarkable than that occupied by Venice in the Middle Ages, or by Liverpool, or New York, in our own times.

Tyre became the commercial emporium of the ancient world, "enriching the kings of the earth with the multitude of her riches, and of her merchandise;" and the constantly increasing demand for the raw materials of her staple manufactures, purple fabrics and bronze, impelled her merchants to push their maritime enterprises further and further, until they created the best fleets and the boldest sailors which the world at that time possessed.

Phœnician factories and fishing stations rapidly extended over the islands of the Ægean into the Black Sea, stretched along both shores of the Mediterranean and reached the Atlantic seaboard in Spain and in Morocco. These energetic sea-folk—fishermen, traders, pirates, or kidnappers, as occasion might offer for the assumption of one or the other character, wherever they touched, carried the arts which they had invented or learned from Egypt or from Babylonia, and stirred the slumbering powers of the teachable savages of Europe with an impulse the traces of which can never be effaced. The European child of to-day, who learns his alphabet, calls the letters by their names simply because the Phœnicians were pleased to make similar figures the symbols of certain sounds. And it is a fair supposition that the Phœnicians may have been driven to invent their alphabet by the inconvenience of ideographic writing for the keeping of the books and the conduct of the correspondence of the great commerce which had grown out of Fishery.

These few remarks must suffice to indicate the wide field of interesting research which fisheries offer to the philosophical historian;

and I pass on to speak of the fisheries from the point of view of our present practical interests.

The supply of food is, in the long run, the chief of these interests. Every nation has its anxiety on this score, but the question presses most heavily on those who, like ourselves, are constantly and rapidly adding to the population of a limited area, and who require more food than that area can possibly supply. Under these circumstances, it is satisfactory to reflect that the sea which shuts us in, at the same time opens up to us supplies of food of almost unlimited extent.

The produce of the sea around our coasts bears a far higher proportion to that of the land than is generally imagined. The most frequented fishing grounds are much more prolific of food than the same extent of the richest land. Once in a year, an acre of good land carefully tilled, produces a ton of corn, or two or three hundredweight of meat or cheese. The same area at the bottom of the sea in the best fishing grounds yields a greater weight of food to the persevering fishermen every week in the year. Five vessels belonging to the same source in a single night's fishing brought in 17 tons weight of fish—an amount of wholesome food equal in weight to that of 50 cattle or 300 sheep. The ground which these vessels covered during the night's fishing could not have exceeded an area of 50 acres.

My colleagues[1] and I made this statement a good many years ago. I have recently tried to discover what yield may be expected, not from the best natural fishing grounds, but from piscicultural operations. At Comacchio, close to the embouchure of the Po into the Adriatic, there is a great shallow lagoon, which covers some 70,000 acres, and in which pisciculture has been practised in a very ingenious manner for many centuries. The fish cultivated are eels, grey mullet, atherines, and soles; and, according to the figures given by M. Coste,[2] the average yield for the sixteen years from 1798 to 1813 amounted to 5 cwt. per acre, that is to say, double the weight of cheese or meat which could have been obtained from the same area of fair pasture land in the same time. Thus the seas around us are not only important sources of food, but they may be made still more important by the artificial development of their resources. But this Exhibition has brought another possibility within the range of practically interesting questions. A short time ago, a visitor to the market might have seen fresh trout from New Zealand lying side by side with fresh salmon, some of which came

[1] Sir James Caird and Mr. G. Shaw Lefevre, M.P. See the Report of the Commissioners appointed to inquire into the Sea Fisheries of the United Kingdom, 1866.

[2] Voyage d'exploration sur le littoral de la France et de l'Italie, 1855.

from Scandinavia and some from the lakes and rivers of North America. Steam and refrigerating apparatus combined have made it possible for us to draw upon the whole world for our supplies of fresh fish. In my boyhood, "Newcastle" was the furthest source of the salmon cried about the streets of London, and that was generally pickled. My son, or at any rate my grandson, when he goes to buy fish, may be offered his choice between a fresh salmon from Ontario and another from Tasmania.

The fishing industry being thus important and thus ancient, it is singular that it can hardly be said to have kept pace with the rapid improvement of almost every other branch of industrial occupation in modern times. If we contrast the progress of fishery with that of agriculture, for example, the comparison is not favourable to fishery.

Within the last quarter of a century, or somewhat more, agriculture has been completely revolutionized, partly by scientific investigations into the conditions under which domestic animals and cultivated plants thrive; and partly by the application of mechanical contrivances, and of steam as a motive power, to agricultural processes.

The same causes have produced such changes as have taken place in fishery, but progress has been much slower. It is now somewhat more than twenty years since I was first called upon to interest myself especially in the sea fisheries; and my astonishment was great when I discovered that the practical fishermen, as a rule, knew nothing whatever about fish, except the way to catch them.

In answer to questions relating to the habits, the food, and the mode of propagation of fishes—points, be it observed, of fundamental importance in any attempt to regulate fishing rationally—I usually met with vague and often absurd guesses in the place of positive knowledge. The Royal Commission, of which I was a member in 1864 and 1865, was appointed chiefly on account of the allegation by the line fishermen that the trawlers destroyed the spawn of the white fish—cod, haddock, whiting, and the like. But, in point of fact, the "spawn" which was produced in support of this allegation, consisted of all sorts of soft marine organisms, except fish. And if the men of practice had then known what the men of science have since discovered, that the eggs of cod, haddock, and plaice float at the top of the sea, they would have spared themselves and their fiellow-fishermen, the trawlers, a great deal of unnecessary trouble and irritation. Thanks to the labours of Sars in the Scandinavian Seas, of the German Fishery Commission in the Baltic and North Sea, and of the United States Fishery Commission in American waters, we now possess a great deal of accurate information about several of the most important of the

food fishes, and the foundations of a scientific knowledge of the fisheries have been laid. But we are still very far behind scientific agriculture ; and, as to the application of machinery and of steam to fishery operations, it may be said that, in this country, a commencement has been made, but hardly more.

This relative backwardness of the fishing industry greatly impressed my colleagues and myself in the course of the inquiries of the Royal Commission to which I have referred ; and I beg permission to quote some remarks on this subject which are to be found in our Report.

"When we consider the amount of care which has been bestowed on the improvement of agriculture, the national societies which are established for promoting it, and the scientific knowledge and engineering skill which have been enlisted in its aid, it seems strange that the sea fisheries have hitherto attracted so little of the public attention. There are few means of enterprise that present better chances of profit than our sea fisheries, and no object of greater utility could be named than the development of enterprise, skill, and mechanical ingenuity which might be elicited by the periodical exhibitions and publications of an influential society specially devoted to the British Fisheries." [1]

I trust that I am not too sanguine in looking upon the crowds who throng to the present remarkable Exhibition as evidence that public attention is now thoroughly attracted to the sea and other fisheries. As this is the third exhibition of its kind which has been held in these islands, I think I may say that the periodical exhibitions for which we ventured to hope have come into existence. And I am thereby encouraged to express a confident belief that our final anticipation will be realized ; and that, in these Conferences, we have the germ out of which, by due process of evolution, a society specially devoted to the promotion of the interests of the Fisheries of these islands may spring.

Whether this vaticination is fulfilled or not, I think that the promoters of this Exhibition may be congratulated on the achievement of a success peculiar to themselves. So far as I know, in no preceding Fishery Exhibition has advantage been taken of the assemblage of so many representatives of fishery interests from all parts of the world—fishery knights and burgesses, if I may so call them—to form a Fishery Parliament such as that at the opening of which your Royal Highness presides to-day. Personally, I should have been very glad if the Conferences could have opened with a com-

[1] Report of the Commissioners appointed to inquire into the Sea Fisheries of the United Kingdom, 1866, p. 17.

munication so full of interest and instruction as that which embodies the results of the practical acquaintance with the sea fisheries gained by His Royal Highness the Duke of Edinburgh during his three years of office as Admiral commanding the Naval Reserves, which you will have the pleasure of hearing to-morrow. But, since the duty of opening the Conferences has been laid upon me, I must endeavour, after these preliminary remarks, to bring under your notice some topic of the same order as those which will be discussed in the Conferences which follow. Of such topics I need hardly say that this Exhibition affords an abundant store. But I have been obliged to pass by many which, under ordinary circumstances, I should have gladly seized upon; because I should not like to be charged with an abuse of my opportunities as first comer by any of the twenty or thirty gentlemen who have undertaken to deal with the subjects of future Conferences.

But on looking over the list of allotted subjects, I find there is yet one important topic unappropriated—unless it belongs to Mr. Shaw Lefevre, in which case I hope that my former colleague will forgive my depredations—and that is the question, WHETHER FISHERIES ARE EXHAUSTIBLE; AND IF SO, WHETHER ANYTHING CAN BE DONE TO PREVENT THEIR EXHAUSTION?

It so happens that I have had occasion to devote very particular attention to these questions, and to express definite opinions about them. And as these opinions seem to me to have been more often attacked than understood, I am glad to have the opportunity of briefly, but I hope clearly, submitting them, with the grounds on which they are based, to your judgment.

Are fisheries exhaustible? That is to say, can all the fish which naturally inhabit a given area be extirpated by the agency of man?

I do not think that this question can be answered categorically. There are fisheries and fisheries.

I have no doubt whatever that some fisheries may be exhausted. Take the case of a salmon river, for example. It needs no argument to convince any one who is familiar with the facts of the case that it is possible to net the main stream, in such a manner, as to catch every salmon that tries to go up and every smolt that tries to go down. Not only is this true, but daily experience in this country unfortunately proves that pollutions may be poured into the upper waters of a salmon river of such a character and in such quantity as to destroy every fish in it.

In this case, although man is only one of many agents which are continually effecting the destruction of salmon in all stages of its existence—although he shares the work with otters and multitudes of

other animals, and even with parasitic plants—yet his intelligence enables him, whenever he pleases, to do more damage than all the rest put together; in fact, to extirpate all the salmon in the river and to prevent the access of any others.

Thus, in dealing with this kind of exhaustible fishery, the principle of the measures by which we may reasonably expect to prevent exhaustion is plain enough. Man is the chief enemy, and we can deal with him by force of law. If the stock of a river is to be kept up, it must be treated upon just the same principles as the stock of a sheep farm.

If an Australian sheep farmer is to be successful in his business he knows very well what he has to do. He must see that his sheep have a sufficient supply of food, he must take care that a sufficient breeding stock is preserved, and he must protect his sheep from all enemies but himself. He must defend his sheep, young and old, not only against the ravages of the wild dog, against infectious diseases, and against parasites; but it is sometimes a very serious matter to protect them against the competition of other herbivorous animals, such as kangaroos, which appropriate the food destined for the sheep. And it is no easy matter to carry out an efficient system of protection. The destruction of the wild dogs may lead to the over multiplication of the kangaroos, and the destruction of the kangaroos may lead the wild dogs to devote their energies too seriously to the sheep. If the sheepowner does not take care what he is about, his very sheep dogs may become disseminators of the staggers among his flock. Moreover, the sheepowner must not let the butcher take more than a certain percentage of his sheep for boiling down, or the stock will be unduly diminished. It is only by incessant attention to all these points that a sheep farmer is successful; and, let him be as attentive as he likes, every now and then some variation in those conditions which are beyond his control —a sudden flood or a long drought, or the straying of a diseased sheep from another run—may bring him to ruin.

Now, if you will consider the action of the conservators of a salmon river, you will see that they, at any rate, strive to do for the salmon that which a careful shepherd does for his sheep. Obstacles in the way of free access to the breeding grounds are removed by the construction of fish passes; the breeding stock is protected by the annual close time; animals which prey on the fish, or compete dangerously with them, are kept down; or the salmon are placed at an advantage by artificially stocking the river. Finally, the destructive agency of man, who plays the part of the butcher, is limited by removal of pollution—by the prohibition of taking parr

and smolts—by the restrictions on the character and on the size of meshes of nets; and, indirectly, by the license duty on nets and rods.

Whether the state of the law is such as to permit the work of the conservator to be carried out sufficiently, or not, is a point which will, I doubt not, be fully discussed by-and-by. All I desire to show is that in principle, the measures adopted by the conservators, if they are to be efficient, must be identical with those of the sheep farmer.

And the analogy is complete, for when the conservator has done all he can, droughts, parasites, and other natural agents which are beyond human control, may nullify his efforts. In the case of the salmon, as in that of the sheep, careful and intelligent protection may promote the prosperity of the stock to any conceivable extent; but it cannot ensure that prosperity, nor prevent immense fluctuations in the yield from year to year.

A salmon fishery then (and the same reasoning applies to all river fisheries) can be exhausted by man because man is, under ordinary circumstances, one of the chief agents of destruction; and, for the same reason, its exhaustion can usually be prevented, because man's operations may be controlled and reduced to any extent that may be desired by force of law.

And now arises the question, Does the same reasoning apply to the sea fisheries? Are there any sea fisheries which are exhaustible, and, if so, are the circumstances of the case such that they can be efficiently protected? I believe that it may be affirmed with confidence that, in relation to our present modes of fishing, a number of the most important sea fisheries, such as the cod fishery, the herring fishery, and the mackerel fishery, are inexhaustible. And I base this conviction on two grounds, first, that the multitude of these fishes is so inconceivably great that the number we catch is relatively insignificant; and, secondly, that the magnitude of the destructive agencies at work upon them is so prodigious, that the destruction effected by the fisherman cannot sensibly increase the death-rate.

At the great cod-fishery of the Lofoden Islands, the fish approach the shore in the form of what the natives call "cod mountains"—vast shoals of densely-packed fish, 120 to 180 feet in vertical thickness. The cod are so close together that Professor Sars tells us "the fishermen, who use lines, can notice how the weight, before it reaches the bottom, is constantly knocking against the fish." And these shoals keep coming in one after another for two months, all along the coast.

A shoal of codfish of this kind, a square mile in superficial extent,

must contain, at the very least, 120,000,000 fish.[1] But it is an exceptionally good season if the Lofoden fishermen take 30,000,000 cod.; and not more than 70,000,000 or 80,000,000 are taken by all the Norwegian fisheries put together. So that one fair shoal of all that approach the coast in the season must be enough to supply the whole of the codfish taken by the Norwegian fisheries, and leave a balance of 40,000,000 or 50,000,000 over.

The principal food of adult cod appears to be herring. If we allow only one herring to each codfish per diem, the cod in a square mile of shoal will consume 840,000,000 herring in a week. But all the Norwegian fisheries put together do not catch more than half that number of herring. Facts of this kind seem to me to justify the belief that the take of all the cod- and herring-fisheries, put together, does not amount to 5 per cent. of the total number of the fish. But the mortality from other sources is enormous. From the time the fish are hatched, they are attacked by other marine animals. The great shoals are attended by hosts of dog-fish, pollack, cetaceans and birds, which prey upon them day and night, and cause a destruction infinitely greater than that which can be effected by the imperfect and intermittent operations of man.

I believe, then, that the cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all the great sea fisheries, are inexhaustible; that is to say, that nothing we do seriously affects the number of the fish. And any attempt to regulate these fisheries seems consequently, from the nature of the case, to be useless.

There are other sea fisheries, however, of which this cannot be said.

Take the case, for example, of the oyster fisheries, so far as it concerns beds which are outside the three-mile limit of the territorial jurisdiction of this country. Theoretically, at any rate, an oyster bed can be dredged clean. In practice, of course, it ceases to be worth while to dredge long before this limit is reached. But we may assume, for the sake of argument, that an oyster bed may be thus stripped. In this case the oyster bed is in the same position as a salmon river. The operations of man bear a very large proportion to the sum of destructive agencies at work, and it may seem that restriction by force of law should be as useful in the one case as in the other.

But it must not be forgotten that the efficacy of salmon protection depends on its completeness. What would be the value of the Salmon Acts if they contained only two provisions—the first that

[1] This allows over four feet in length for each fish, and a yard between it and those above, below, and at the sides.

there shall be an annual close time, and the second that no parr or smolts shall be captured? Is it not obvious that there would be as good as no protection at all, inasmuch as every salmon that tried to ascend the river might be captured during the open season, and then, of course, there would be neither breeding fish nor smolts to protect?

And yet this is all that the restrictions on oyster fishing enforced in this country have ever aimed at.

At one time, we enforced an annual close time, and we said that oysters below a certain size should not be taken; but I am at a loss to divine how the strictest enforcement of these regulations could prevent any one from stripping a bed bare of every adult oyster during the open season. But the interference with the removal of oysters below a certain size is so obviously a measure in the interest of dogwhelks and star-fish, and against man, that we have given that up, and now we only insist upon the four months' close time; which appears to me to be just as rational as it would be to prohibit the catching of salmon in December, January, and February, and to permit the destruction of young and old by all imaginable means, and to any extent, during the rest of the year.

The only protection of oysters which can possibly be efficient is some such system as that pursued in Denmark and in France—where the beds are the property of the State—where an estimate is made of the quantity of oysters in a bed—and where fishing is permitted only to the extent justified by that estimate.

How far the results of such a system of protection of oyster beds justify its adoption is a question which I will not at present attempt to discuss; but I think it must be perfectly clear to every one acquainted with the circumstances of our deep-sea oyster beds, that it is utterly impracticable to apply any such system to them. Who is to survey these beds? Who is to watch them? Who is to see that the dredgers do not take more than their allotted share? Who is to prevent fishermen sailing under the flag of a nation with which we have no fishery convention from disregarding our regulations?

Thus I arrive at the conclusion—first, that oyster fisheries may be exhaustible; and, secondly, that for those which lie outside the territorial limit no real protection is practically possible. In the case of the oyster fisheries which lie inside the territorial limit the case is different. Here the State can grant a property in the beds to corporations or to individuals whose interest it will become to protect them efficiently. And this I think is the only method by which such fisheries can be preserved.